Public Meeting on Research: Air Pollution Health Outcomes and Valuation

March 22, 2023

Welcome

Elizabeth Scheehle, Chief, Research Division

Bonnie Holmes-Gen, Chief, Health & Exposure Assessment Branch

Before We Begin…

- Meeting is being recorded.
- ADA-compliant slides will be posted on the website (registrants will receive a notice when they are posted).
- If you have any technical issues *during* the meeting, please email my colleague, Dr. Arash Mohegh, arash.mohegh@arb.ca.gov

Agenda

9am
- **Introduction**
- **Research on Air Pollution and Health Outcomes & Community Health Issues**
  - Presentations
  - Panel discussion with Scientific Health Experts

11am
- **BREAK (10 min)**
- **Approaches for Health Benefit Valuation**
  - Presentations
  - Panel discussion with Scientific Health Experts

12pm
- **Public comment**
- **Closing**

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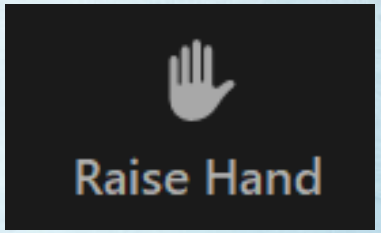
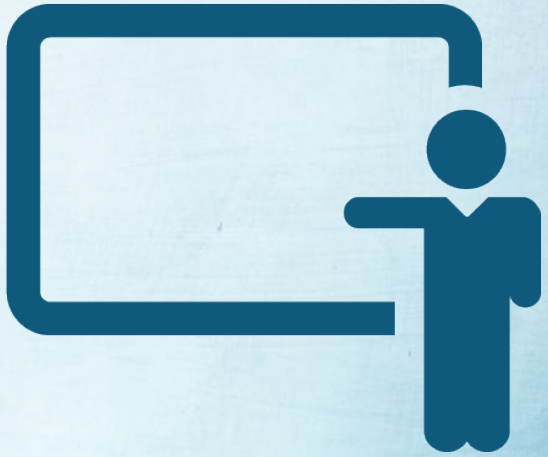
Format for Public Comment

- We will have a public comment period at the end of the meeting
  - To provide verbal comment, you may raise your hand to be added to the speaking queue.
  - Leave your hand raised until you are called upon to provide your comment.
  - Comments are limited to 2 minutes.
- Online public comment log will be open after the meeting (registrants will receive a notice when this is open for submissions).



Purpose of Meeting

- Hear about science in the area of air pollution and health
- Better understand the current available research and methodologies to assess and quantify health outcomes and benefits

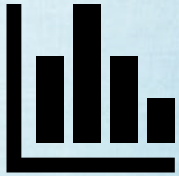


What are Health Endpoints?

- An adverse health outcome used for purposes of evaluating quantitative or qualitative health impacts
  - Examples: mortality and morbidity effects such as premature deaths or hospitalizations from air pollution exposure
- Can be used to evaluate effects from air pollution such as criteria pollutants or air toxics

CARB's Current Health Analysis

- Informs the benefits of CARB regulations, plans, and programs.
- Quantitative analysis: analyzes cases reduced and provides monetization for endpoints including:
  - Cardiopulmonary mortality
  - Hospitalizations for heart and lung causes
  - Emergency room visits for asthma
- Qualitative analysis: summarizes health effects, provides directional analysis based on literature
  - Ex. 2022 Scoping Plan Appendix G: Public Health



CARB Board Directed Expansion of Health Analysis

Goal: Develop Methods for More Comprehensive Evaluation of Health Benefits

- New qualitative and quantitative approaches
- Assess health impacts in disadvantaged communities
- Quantify additional pollutants
- Update health endpoints from pollution exposure
- Assess and communicate GHG reduction benefits

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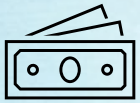
Expanded $PM_{2.5}$ Health Endpoints

Updated Endpoints	New Endpoints
Cardiovascular Hospital Admissions	Cardiovascular ED Visits
Respiratory Hospital Admissions	Acute Myocardial Infarction, Nonfatal
Respiratory ED Visits	Asthma Onset
	Asthma Symptoms / Exacerbation
	Lung Cancer Incidence
	Lost Work-Days
	Alzheimer's Disease
	Parkinson's Disease






- Described in Bulletin released Nov 2022
- Initial phase of project to expand health analysis
- Response to recent research and Board direction

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US EPA $PM_{2.5}$ Causality Determinations

Health Endpoint	Short-Term (ST) or Long-Term (LT)	2019 ISA Causality
Respiratory Effects	ST	Likely to be causal
	LT	Likely to be causal
Cardiovascular Effects	ST	Causal
	LT	Causal
Metabolic Effects	ST	Suggestive of, but not sufficient to infer
	LT	Suggestive of, but not sufficient to infer
Nervous System Effects	ST	Suggestive of, but not sufficient to infer
	LT	Likely to be causal
Reproductive and Developmental Effects	Male and Female Reproduction and Fertility	Suggestive of, but not sufficient to infer
	Pregnancy and Birth Outcomes	Suggestive of, but not sufficient to infer
Cancer	---	Likely to be causal
Mortality	ST	Causal
	LT	Causal

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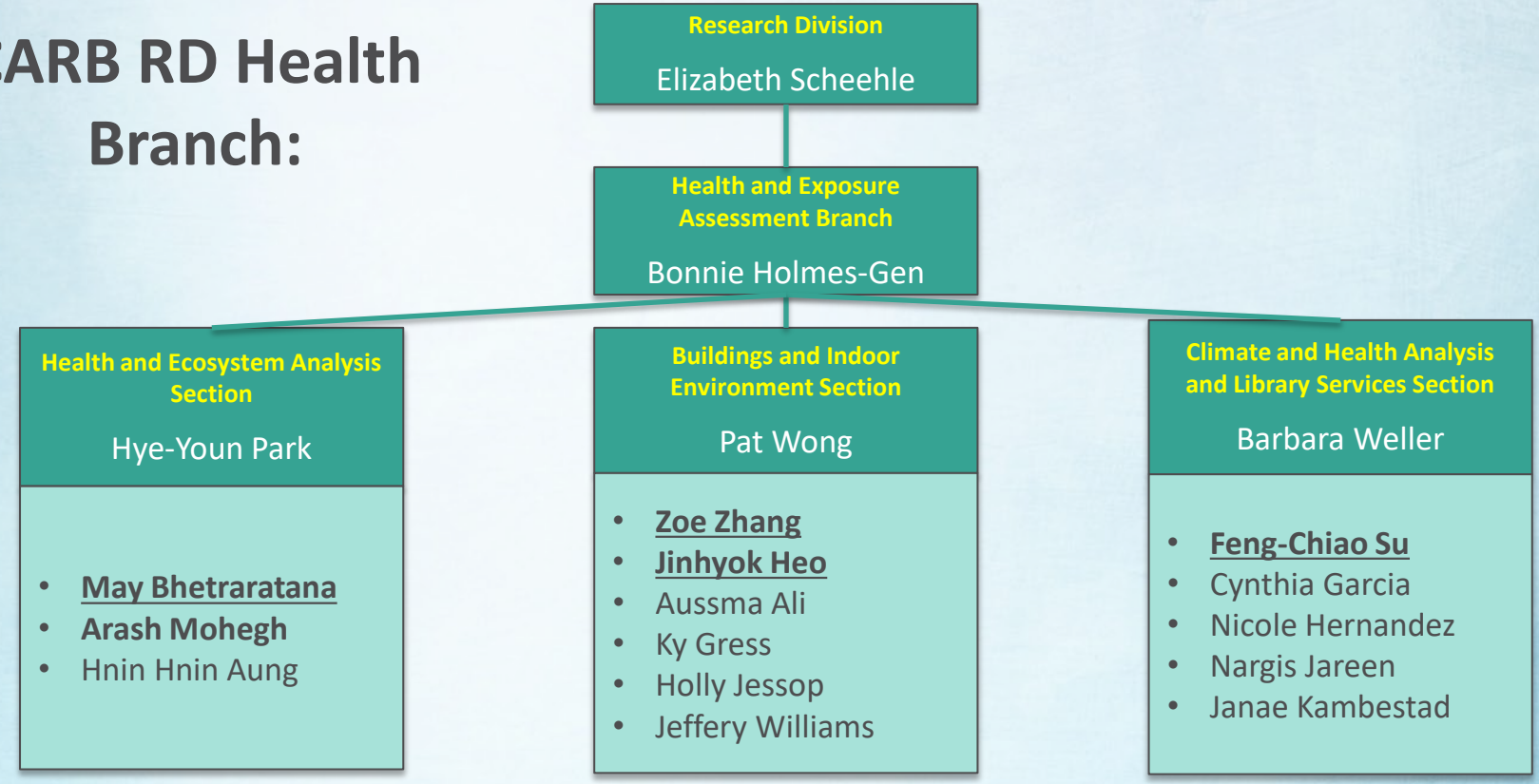
CARB-Funded Health Research Summary

Recently Completed	**Non-exhaust health impacts** (UCLA) **PM2.5 and lost workdays** (UCLA)	**Asthma medication use** – GPS inhalers, statewide (UC Berkeley) and SoCal (UC Berkeley)
Ongoing	**Natural & Working Lands health analysis tool** (UCLA) **Birth Outcomes and Neuro-degenerative** (UCLA) **Children's Neuro-development** (UC Berkeley)	**Tracking health benefits of priority communities** (UCLA/PHI) **Sub-chronic effects of wildfire smoke** (UCI) **Metabolic outcomes** (UC Berkeley)
Upcoming Contracts	**Health impacts of land-management to reduce wildfire** **Combined impacts of climate change stressors** **Health and economic benefits of cancer risk reduction** **Impacts of air pollution across multiple generations**	

CARB RD Health Branch:



Scientific Health Expert Panelists

Irva Hertz-Picciotto, PhD, MPH

Professor and Vice Chair for Research

Director, UC Davis Environmental Health Sciences Center

Dept of Public Health Sciences

UC Davis, School of Medicine

Michael Jerrett, PhD

Director, UCLA Center for Occupational & Environmental Health

Co-Director, Center for Healthy Climate Solutions

Professor, Dept of Environmental Health Sciences, UCLA Fielding School of Public Health

Rob McConnell, MD

Professor of Population and Public Health Sciences

Director, Southern California Environmental Health Sciences Center

USC

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Penelope JE (Jenny) Quintana, PhD, MPH

Professor, Division of Environmental Health and Associate Director for Student Affairs

School of Public Health

San Diego State University

Bhavna Shamasunder, PhD, MES

Chair & Associate Professor, Urban & Environmental Policy

Occidental College

Tracey J. Woodruff, PhD, MPH

Alison S. Carlson Endowed Professor and Director, Program on Reproductive Health and the Environment & Environmental Research and Translation for Health (EaRTH) Center

UCSF

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Presenters & Topics:

Research on Air Pollution and Health Outcomes & Community Health Issues

Rupa Basu, PhD, MPH
OEHHA
Topic: birth outcomes

Sadeer Al-Kindi, MD
Case Western Reserve University
Topic: metabolic outcomes (diabetes)

Stephanie M. Holm, MD, PhD, MPH
UCSF
Topic: neurodevelopmental outcomes

Bhavna Shamasunder, PhD, MES
Occidental College
Topic: health impacts in vulnerable communities

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Rupa Basu, PhD, MPH

Chief, Air and Climate Epidemiology Section

Office of Environmental Health Hazard Assessment (OEHHA)

Dr. Basu has published extensively on research focusing on examining temperature and air pollution on health outcomes, including mortality, morbidity, and adverse birth outcomes, while identifying vulnerable subgroups. Prior to joining OEHHA, she worked at the US Environmental Protection Agency. She was featured in the Emmy award-winning climate change documentary, Years of Living Dangerously, “Mercury Rising” episode with Matt Damon. Dr. Basu’s work is widely cited and has received a lot of media attention, including The New York Times, The New Yorker, LA Times, SF Chronicle, National Public Radio, and BBC World News.

AIR POLLUTION AND ADVERSE BIRTH OUTCOMES

Rupa Basu, PhD, MPH
Chief, Air and Climate Epidemiology Section

Amal Syed, MPH
Research Scientist

Office of Environmental Health Hazard Assessment

March 22, 2023

OEHHA
California Office of Environmental Health Hazard Assessment

Outline

- Introduction to OEHHA
- Overview of OEHHA's research
  - $PM_{2.5}$ and constituents
  - Disproportionate effects on minority communities
  - Critical exposure windows during gestation
  - Mental health impacts of $PM_{2.5}$
- Potential biological mechanisms
- Summary

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OEHHA: What We Do

Epidemiologic research on health effects of heat and air pollution

Climate change research and evaluations

Place-based cumulative impact and EJ evaluations

Risk Assessments and risk method development

Biomonitoring

Pesticide community training, monitoring, and peer review

Proposition 65

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$PM_{2.5}$ and $PM_{2.5}$ Constituents Associated with Low Birth Weight

- Full gestational exposures to $PM_{2.5}$ and several $PM_{2.5}$ constituents significantly associated with reductions in term birth weight.
- $PM_{2.5}$ constituents (sulfur, sulfur dioxide, vanadium, iron, manganese, bromine, ammonium, zinc and copper) had greatest impacts.
- Reductions in birth weight were generally larger among younger mothers and varied by race/ethnicity and from traffic-related particles

Basu et al, *Environmental Research*, 2014.

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$PM_{2.5}$ and Constituents also Associated with Preterm Delivery

$PM_{2.5}$ constituents, such as ammonium, nitrate and bromine often linked to traffic and biomass combustion most highly associated with preterm delivery

Greater associations for blacks, Asians, older maternal age, having some college education, and gestational weeks 32-34

Paediatric and Perinatal Epidemiology

424

doi: 10.1111/ppe.12380

Association between $PM_{2.5}$ and $PM_{2.5}$ Constituents and Preterm Delivery in California, 2000–2006

Rupa Basu, Dharshani Pearson, Keita Ebisu, Brian Malig

Air and Climate Epidemiology Section, California Office of Environmental Health Hazard Assessment, Oakland, CA

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California Office of Environmental Health Hazard Assessment

Adverse Birth Outcomes from $PM_{2.5}$ Vary By Race/Ethnicity

Infants born to Non-Hispanic black people were more vulnerable to low birth weight from $PM_{2.5}$ exposure

Original Research

ISEE ENVIRONMENTAL EPIDEMIOLOGY

OPEN

A quantile regression approach to examine fine particles, term low birth weight, and racial/ethnic disparities

Lara Schwarz[a,b], Tim Bruckner[c], Sindana D. Ilango[a,b], Paige Sheridan[a,b], Rupa Basu[d], Tarik Benmarhnia[a,e*]

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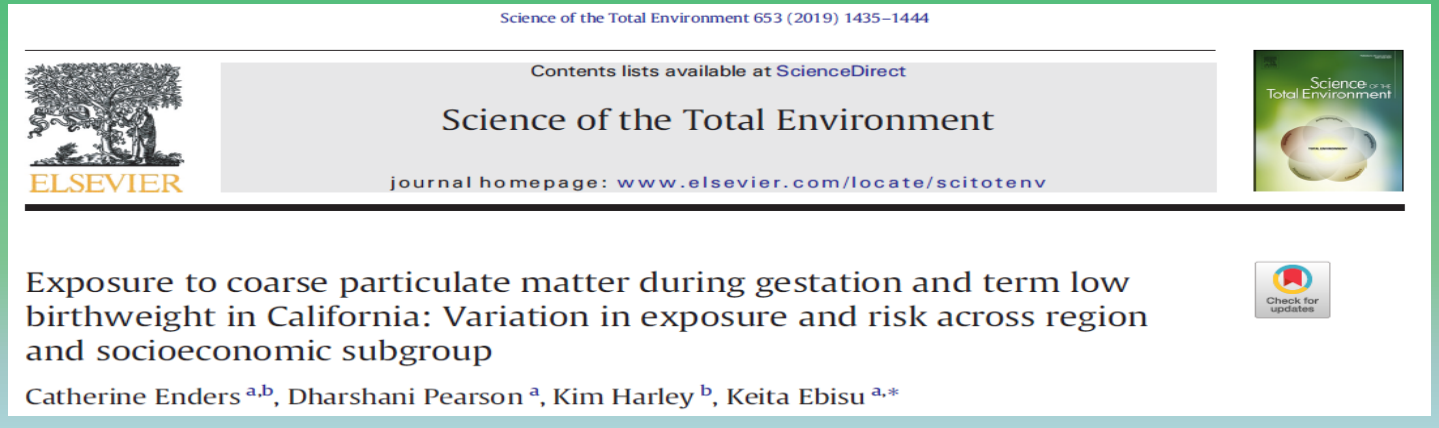
California Office of Environmental Health Hazard Assessment

$PM_{10-2.5}$ (Coarse Particles) and Low Birth Weight Varies by Socioeconomic Status

Greater among Non-Hispanic black people and living in the Central Valley



Science of the Total Environment 653 (2019) 1435–1444

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Exposure to coarse particulate matter during gestation and term low birthweight in California: Variation in exposure and risk across region and socioeconomic subgroup

Catherine Enders [a,b], Dharshani Pearson [a], Kim Harley [b], Keita Ebisu [a,*]

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Critical windows of exposure related to preterm birth

- $PM_{2.5}$ exposure during a full pregnancy had the greatest association with preterm birth

- Gestational weeks 17–24 and 36 associated with increased vulnerability to exposure

American Journal of Epidemiology

Vol. 188, No. 9
DOI: 10.1093/aje/kwz120
Advance Access publication:
May 20, 2019

Original Contribution

Ambient Fine Particulate Matter and Preterm Birth in California: Identification of Critical Exposure Windows

Paige Sheridan*, Sindana Ilango, Tim A. Bruckner, Qiong Wang, Rupa Basu, and Tarik Benmarhnia

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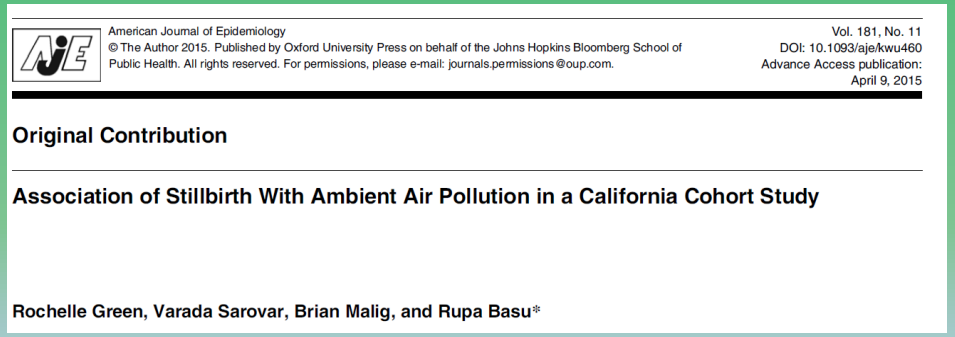
Critical windows of exposure related to stillbirth

Long-term $PM_{2.5}$ or NO_2 exposure during entire pregnancy and O_3 exposure during the third trimester associated with stillbirth

Short-term SO_2, O_3 and $PM_{10-2.5}$ associated with stillbirth within one week



American Journal of Epidemiology
Vol. 181, No. 11

DOI: 10.1093/aje/kwu460
Advance Access publication: April 9, 2015

Original Contribution

Association of Stillbirth With Ambient Air Pollution in a California Cohort Study

Rochelle Green, Varada Sarovar, Brian Malig, and Rupa Basu*

Environmental Research 191 (2020) 110103

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

A case-crossover study of short-term air pollution exposure and the risk of stillbirth in California, 1999–2009

Varada Sarovar [a,b,1], Brian J. Malig [a,*,1], Rupa Basu [a]

[a] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Oakland, CA, USA
[b] Division of Biostatistics, School of Public Health, UC Berkeley, Berkeley, CA, USA

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Systematic Review on PM2.5, Ozone and Heat Exposure on Adverse Birth Outcomes

- 57 of 68 studies from 2007 through 2019 had statistically significant associations
- Disparities by race/ethnicity and pre-existing conditions such as asthma

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Recent Study on $PM_{2.5}$ and Mental Health

Significant Associations Between Air Pollutants and Mental Health Outcomes

	Same-day Mean $PM_{2.5}$	7-day Lag O_3	30-day Lag O_3
All Mental Health Outcomes	X	X	
Homicide/Inflicted Injury	X		X
Neurotic Disorders	X		X
Depression		X	
Self-harm/Suicide		X	
Bipolar Disorder		X	

Nguyen, Malig and Basu, PLOS One, 2021

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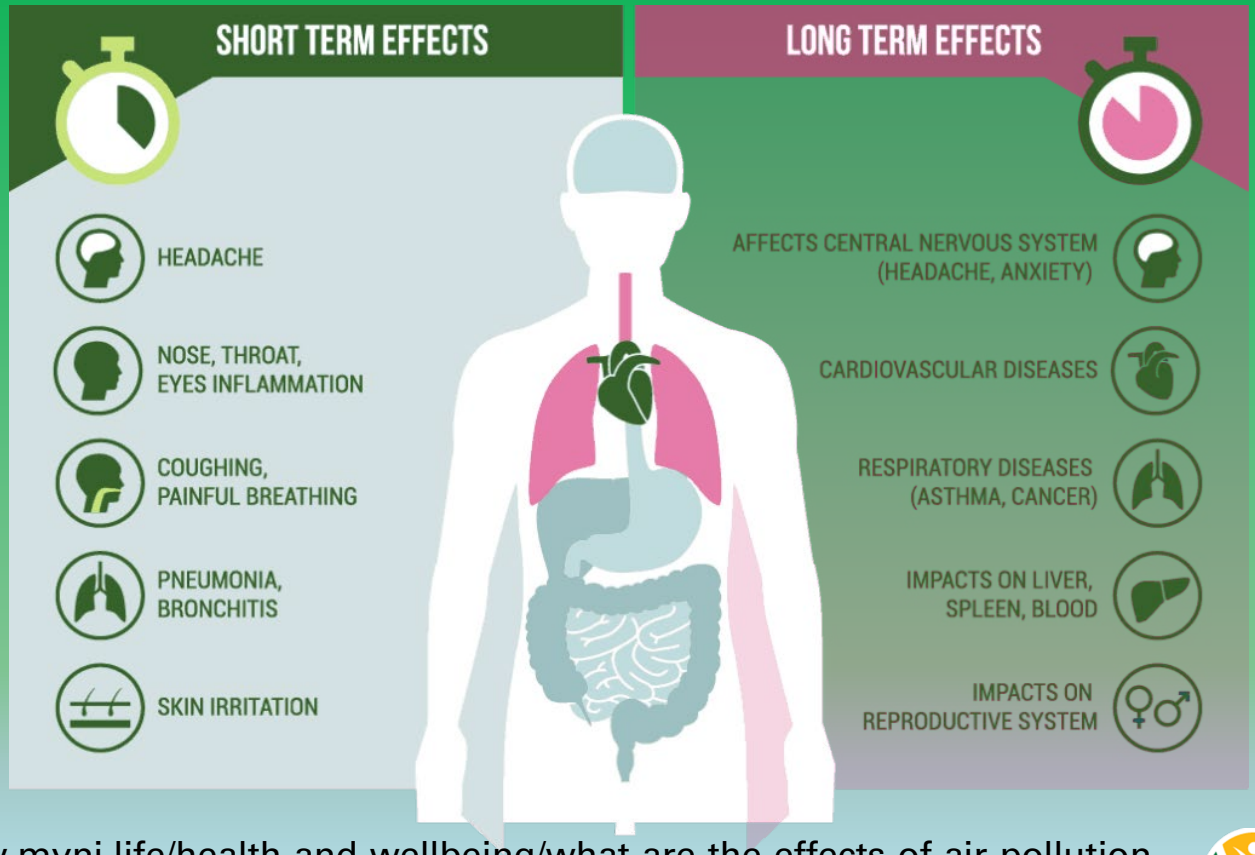
Physiological Effects of Air Pollution



https://www.myni.life/health-and-wellbeing/what-are-the-effects-of-air-pollution-on-the-human-body/

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Summary

- Air pollutants are associated with adverse birth outcomes such as low birth weight, preterm delivery and stillbirth.
- In California, these effects were more pronounced with traffic-related particles and among non-Hispanic black people.
- Full pregnancy $PM_{2.5}$ exposure has been found to have a greater impact.
- Important to explore and identify critical windows of exposure for both short-term and long-term particulate matter exposure.
- $PM_{2.5}$ also exacerbates mental health impacts.

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THANK YOU!

Questions?
Rupa.Basu@oehha.ca.gov

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California Office of Environmental Health Hazard Assessment

Stephanie Holm, MD, PhD, MPH

Director, Western States Pediatric Environmental Health Specialty Unit

Assistant Clinical Professor, UCSF Division of Occupational, Environmental and Climate Medicine

Dr. Holm received her medical degree in 2011 from the University of Pittsburgh and her PhD in 2021 in environmental epidemiology at UC Berkeley. She is board certified in both pediatrics and occupational/environmental medicine. She is the Director of the Western States Pediatric Environmental Health Specialty Unit, which works on education and research translation of environmental health topics for the public. Her ongoing research activities include work on outdoor air pollution and its effects on metabolic and neurologic outcomes in children, as well as work on cooking-related indoor air pollution and associated health effects in children.

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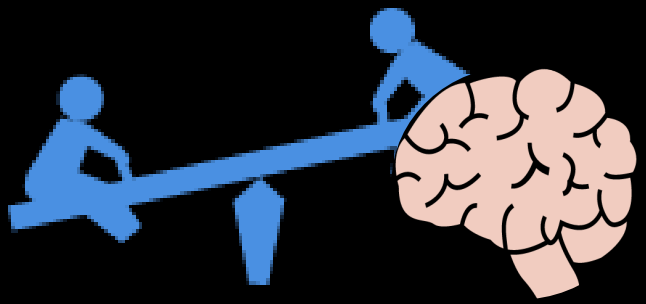


Neurodevelopmental Health Outcomes from Air Pollution

Stephanie Holm, MD PhD MPH

UCSF University of California San Francisco

WESTERN STATES PEHSU Pediatric Environmental Health Specialty Unit

Berkeley UNIVERSITY OF CALIFORNIA

Outline

Mechanisms

Air pollution effects on the brain throughout lifecourse

Why children are particularly vulnerable

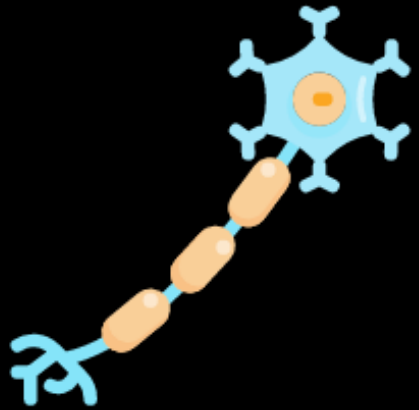
Neurodevelopmental effects of air pollution exposure prenatally and in childhood

Some of my work in the area

Mechanisms

Increased Permeability of the Blood-Brain Barrier

Costa et al 2017, Calderon-Garciduenas 2008, Oberdoerster et al 2008, Oppenheim et al 2013



Direct Effects on Neurons

Fagundes et al 2015, Solaimani et al 2017, Wei et al 2016, Klocke et al 2018

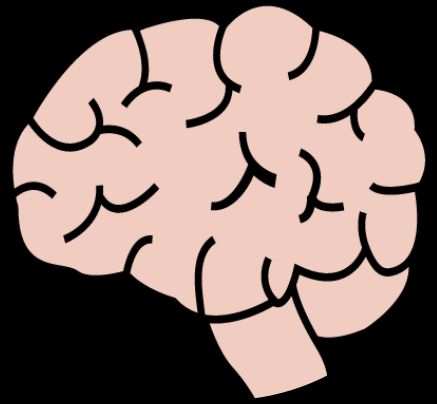
Systemic inflammation leading to Neuroinflammation

Bolton et al 2012, Bos et al 2012, Levesque et al 2011, Calderon-Garciduenas 2008

Neurodevelomental effects of Exposure to Air Pollution

- Neurocognitive effects of PM across the life course (Payne-Sturges et al 2019, US EPA 2019, Suades-Gonzalez et al 2015).

- Changes in brain structure and connectivity on MRI (Guxens et al 2022)



Why are Children More Vulnerable?

1. Differences in Physiology that increase Dose
2. Unique Windows of Development
3. Behaviors and Preferences that Increase Exposure

Holm et al 2020

Neurocognitive effects of Prenatal exposures

- Cognition
  - Decrease in intelligence in preschool-aged children associated with prenatal exposure to multiple air pollutants including PM, BC, PAH , NO_2
  - Some mixed evidence, a large pooling of European birth cohorts did not find neurodevelopmental effects of in-utero exposure (Guxens et al 2014)

Systematic Reviews/Meta-analyses (Clifford et al 2016, Castagna et al 2022, Volk et al 2021). Individual studies (Chiu et al 2016, Jurtado-Diaz et al 2021, Lerxundi et al 2015, Kim et al 2014, Yorifuji et al 2016, Edwards et al 2010, Perera et al 2009, Porta et al 2016, Porta et al 2016, Harris et al 2016)

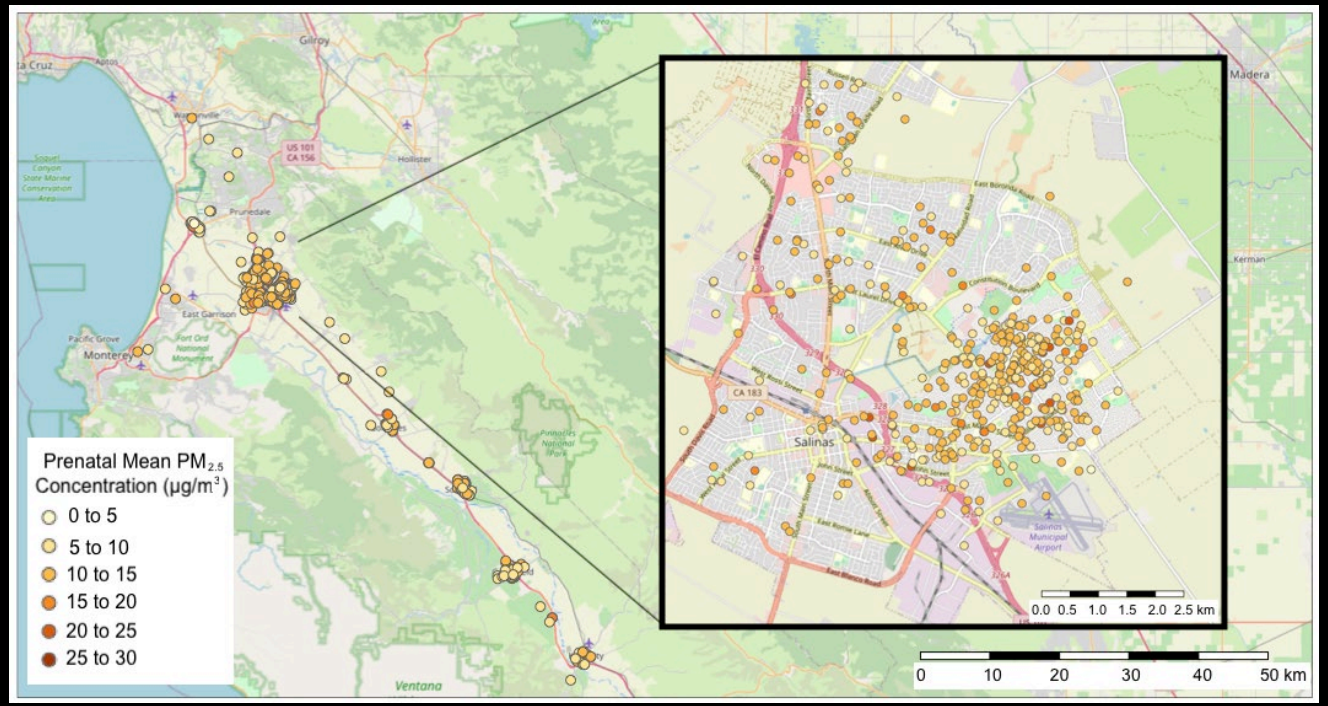
Neurocognitive effects of Prenatal exposures

- Autism
  - Multiple prior systematic reviews and meta-analyses, strong evidence for perinatal period (prenatal and early infancy) (Volk et al 2021)
- Motor skills
  - Large birth cohort increased $PM_{2.5}$ exposure associated with decrements in gross and fine motor skills, social skills (Shih et al 2022)
- Association with preterm birth and low-birth weight, also associated with neurodevelopmental disorders
  - Recent study showing that cognitive effects are not mediated through preterm birth (Balalian et al 2020)

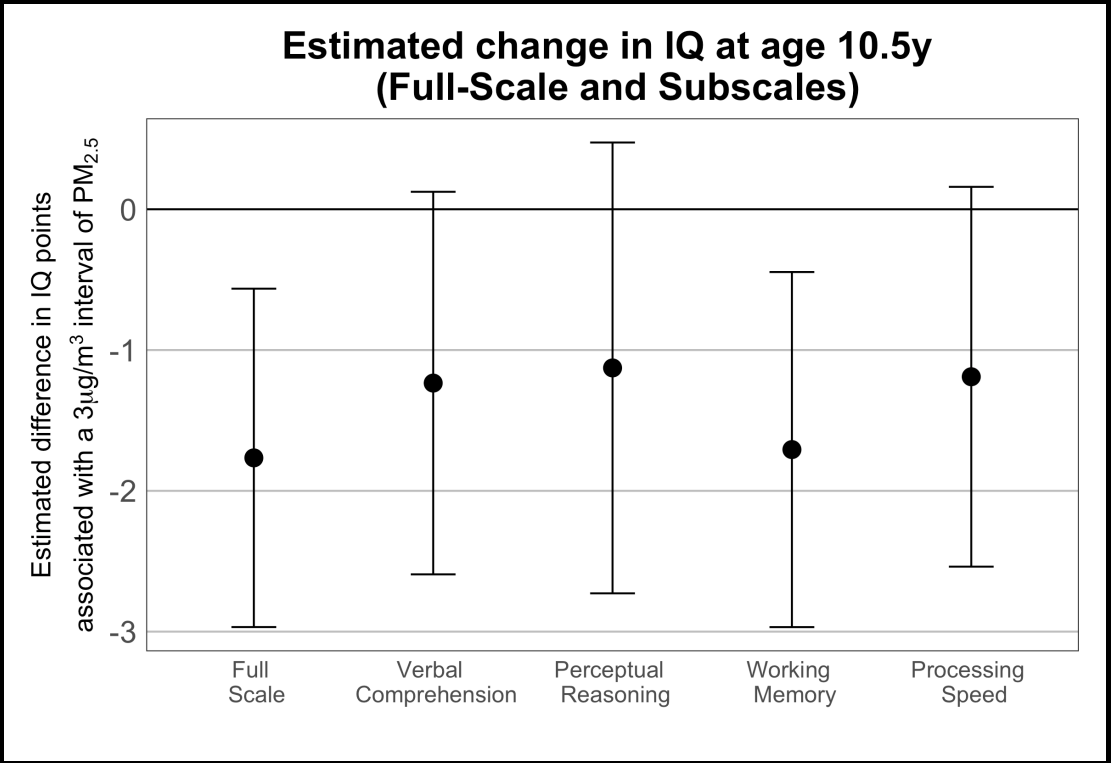
Neurocognitive effects of Childhood exposure

- Cognition
  - $PM_{2.5}$ exposure and decrements in childhood cognitive function (Clifford et al 2018, WHO 2018, Volk et al 2021)
  - School performance (Lu et al 2021, Stenson et al 2021, Sunyer et al 2015, Wang et al 2009)
- Attention
  - In two German cohorts, increased risk of hyperactivity and inattention at age 15 associated with $PM_{2.5}$ (Fuertes et al 2016).
  - 2022 Systematic review describes consistent evidence for attention effects (Castagna et al 2022)
    - Possibly higher risk in those with APoE e4 allele
- Behavior
  - monthly $PM_{2.5}$ levels over prior couple years were associated with increased risk of delinquent behavior in adolescents (Younan et al 2017).

CHAMACOS Prenatal Air Pollution and Child IQ



Key Findings



- Decreases in childhood IQ associated with $PM_{2.5}$ exposure in-utero (larger effect than previously seen, and in older kids)
- Particularly strong effect in mid-late pregnancy
- Different patterns of effect between groups defined using the sex of the child assigned at birth, both in terms of subscales and timing of exposure

CHAPS: StaCK

Children's Health and Air Pollution Study: Standardized assessments and Cognition in Kids

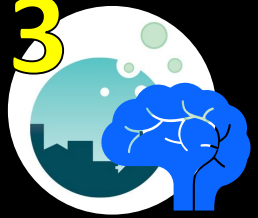
1

Systematic review: studies of air pollutant exposure and standardized test scores

2

Analysis of $PM_{2.5}$, diesel and traffic density in California schools regressed on standardized test performance

3

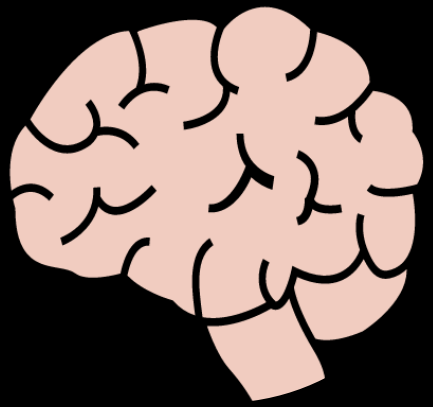


Within the CHAPS cohort, assess cognition, attention, behavior, mood, standardized test performance & biomarkers, associate with $PM_{2.5}$, NO_2, PAH, BC

4

Estimate benefits to California of improvements in air pollution

Summary



- There is consistent evidence of neurodevelopmental effects from both prenatal and childhood exposure to air pollution
  - Further exploration is needed to describe magnitudes of effects, particularly critical windows, particularly sensitive populations, duration of effects
- Shifting the entire distribution of cognition can have huge societal effects
- Effects on cognition and neurodevelopmental disorders can have lifelong impacts that affect health and quality of life (i.e. earning potential)

Thanks!

CHAMACOS

Brenda Eskenazi, PhD

Kim Harley, PhD

Katie Kogut, MPH MSc

Bob Gunier, PhD MPH

John Balmes, MD

CHAPS

Nina Holland, PhD

Betsey Noth, PhD

Tim Tyner, MS

Liza Lutzker, MPH

John Balmes, MD

Sadeer Al-Kindi, MD

Cardiologist; Assistant Professor

Case Western Reserve University

Dr. Al-Kindi is a cardiologist and clinical-translational researcher in environmental health effects and cardiovascular prevention.

CARB

Air Pollution and Metabolic Disease: Insights from Mechanistic and Human Studies

Sadeer Al-Kindi, MD, FACC

Assistant Professor of Medicine, Radiology, and Biomedical Engineering
Faculty Affiliate, Swetland Center for Environmental Health
Wolfe Family Scholar in Cardiovascular Research
Director, Cardiovascular Phenomics Core
Co-Director, Center for Novel Approaches in Vascular-Metabolic Disease
Case Western Reserve University School of Medicine
Cleveland, OH

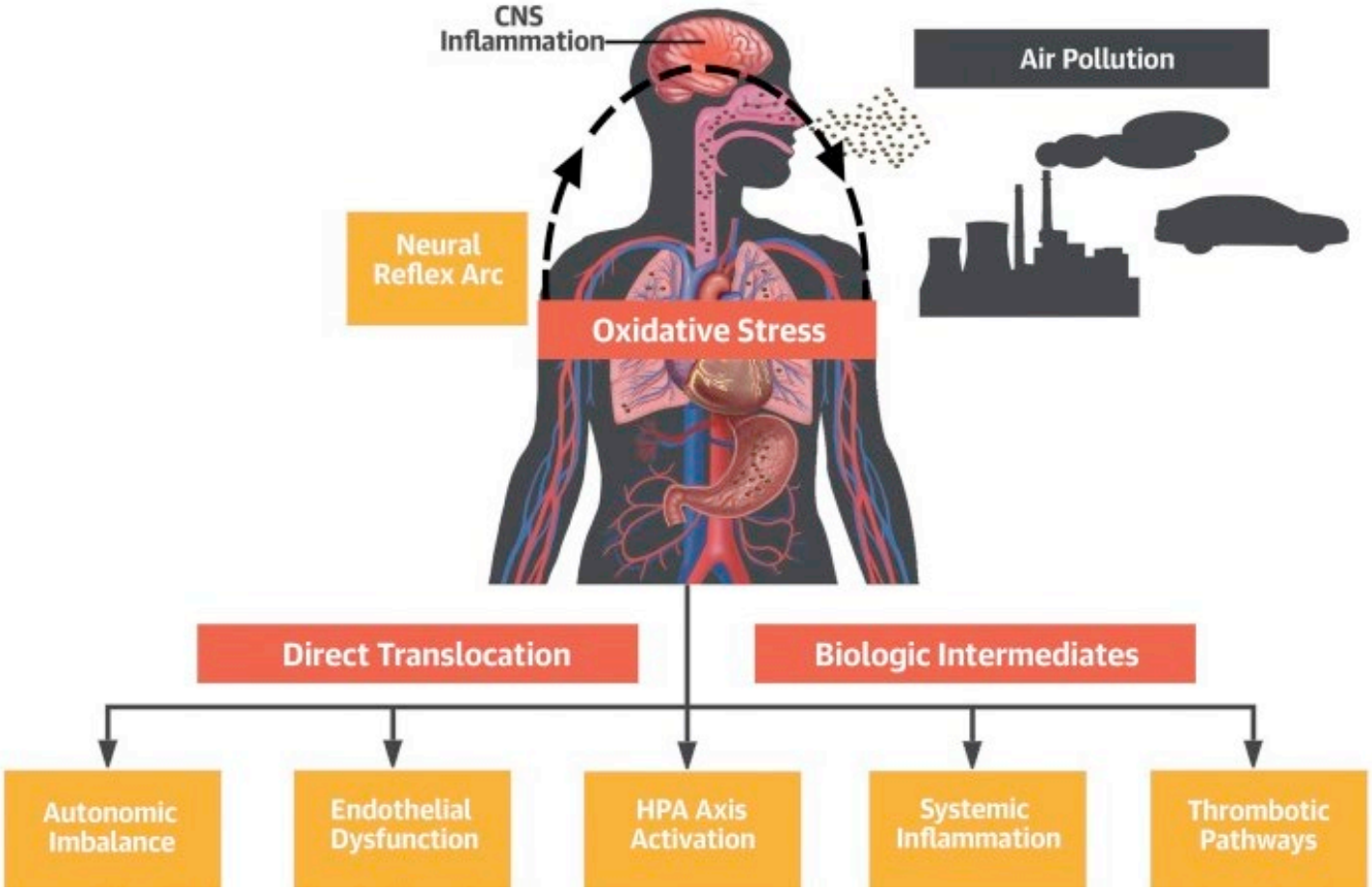
University Hospitals
Harrington Heart & Vascular Institute
Cleveland | Ohio

SCHOOL OF MEDICINE
CASE WESTERN RESERVE UNIVERSITY

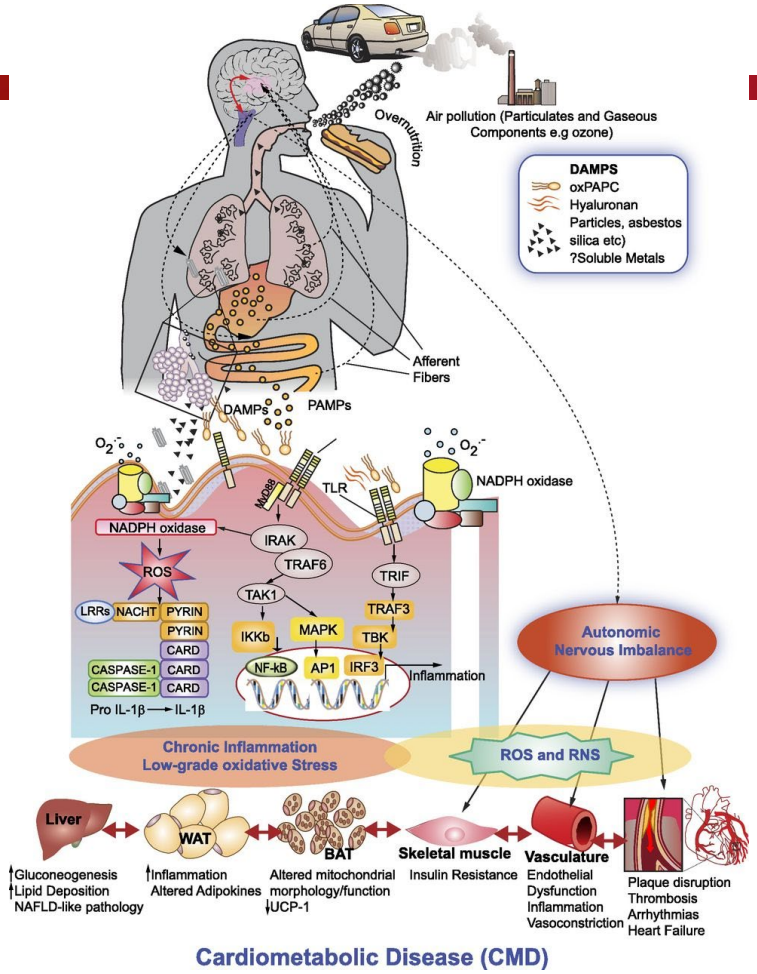
Disclosures:

- No financial disclosures

- Investigator on the CARB-funded UC Berkeley Project to Investigate Metabolic Outcomes of Air Pollution Exposure

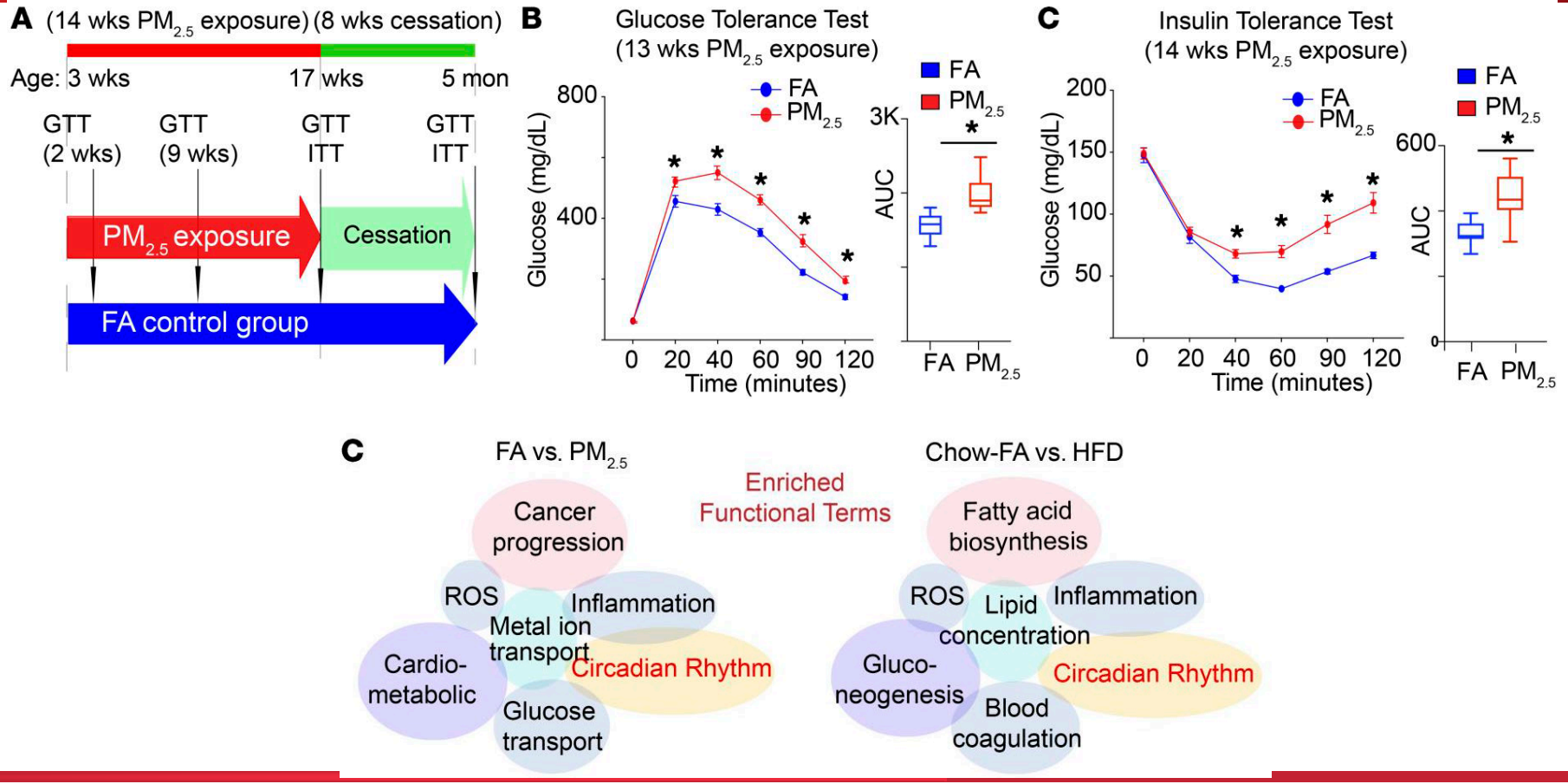

CNS Inflammation
Air Pollution
Neural Reflex Arc
Oxidative Stress
Direct Translocation
Biologic Intermediates
Autonomic Imbalance
Endothelial Dysfunction
HPA Axis Activation
Systemic Inflammation
Thrombotic Pathways

Mechanistic Insights

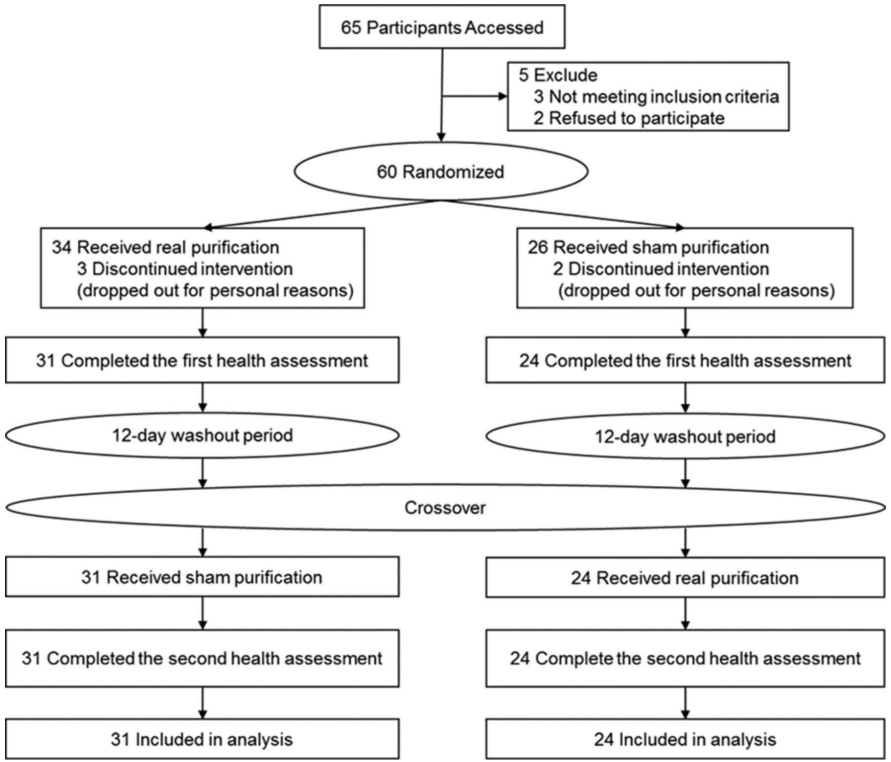


Rajagopalan, Al-Kindi, et al. JACC 2019

PM2.5 exposure leads to insulin resistance + glucose intolerance, and broad transcriptomic changes in insulin-sensitive tissues

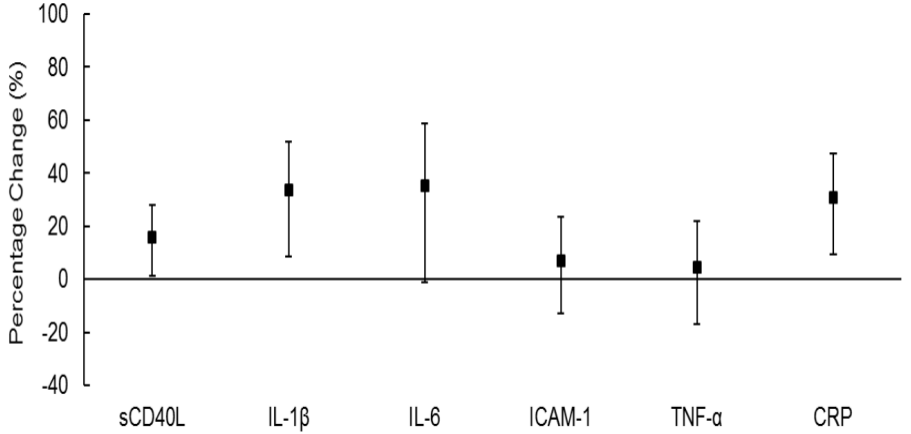


55 healthy college students in Shanghai, China HEPA vs Sham Indoor Air Filtration (9 days with a 12-day washout period)

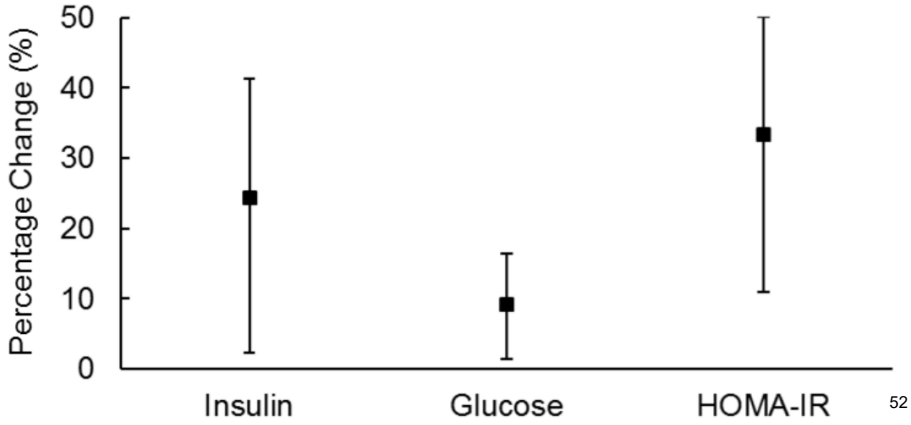


Li et al. Circulation. 2017;136:618–627

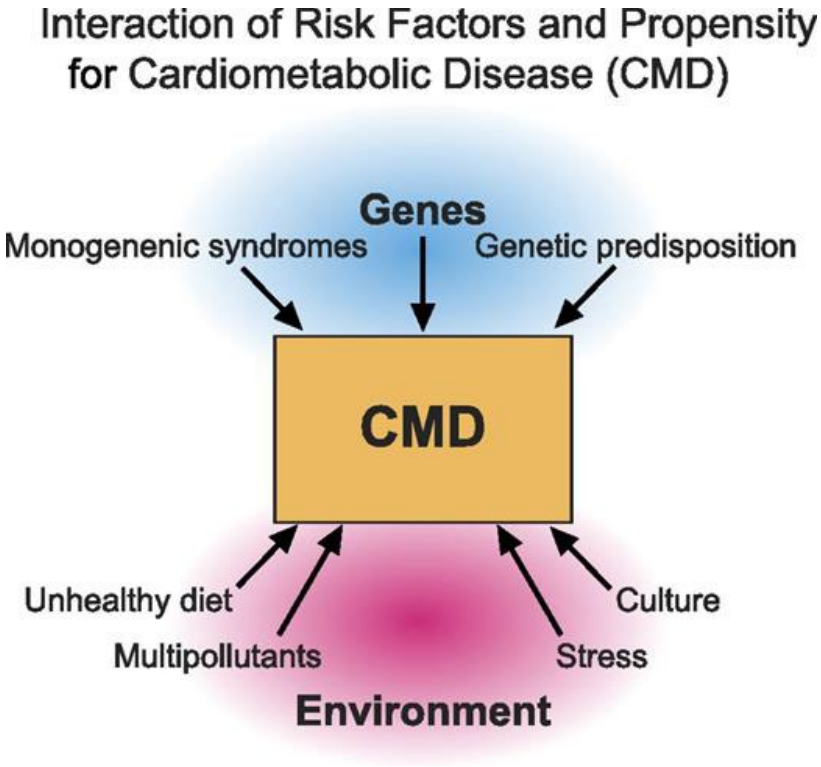
% Reduction of Inflammatory Markers (HEPA vs Sham Filtration)



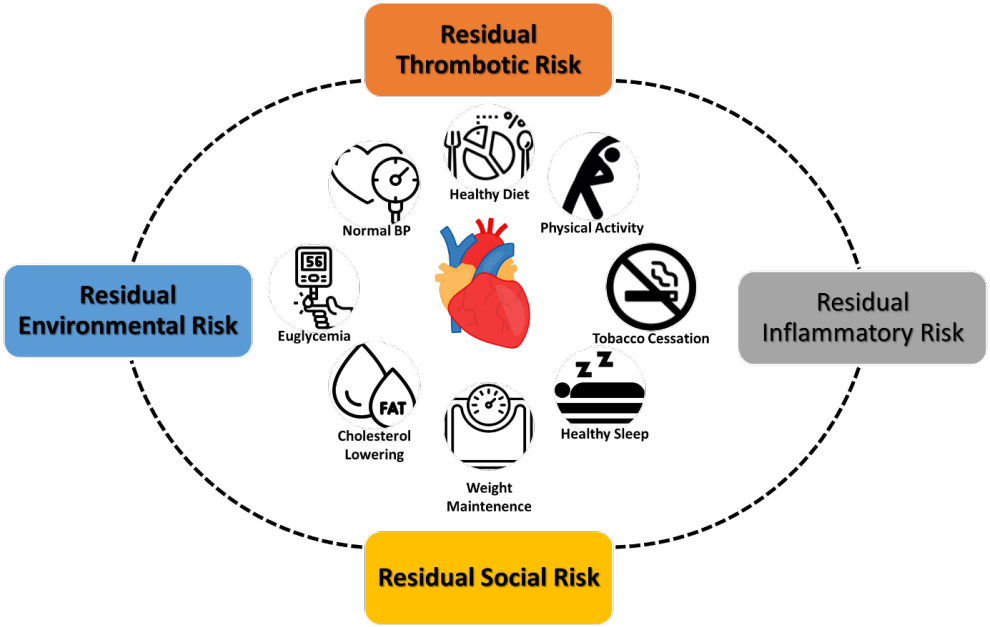
% Reduction of Metabolic Markers (HEPA vs Sham Filtration)



Objectives

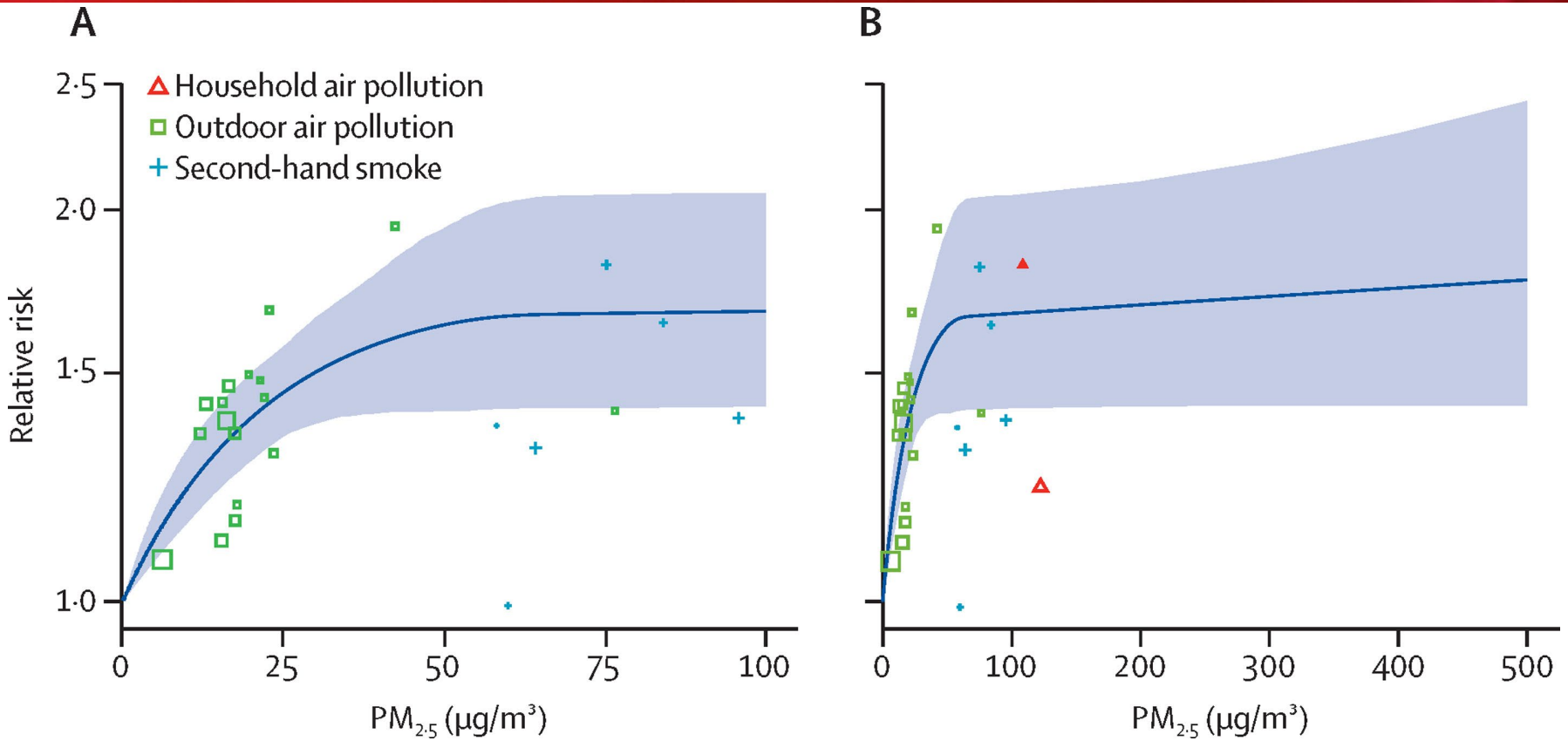


Rajagopalan & Brook. Diabetes 2012



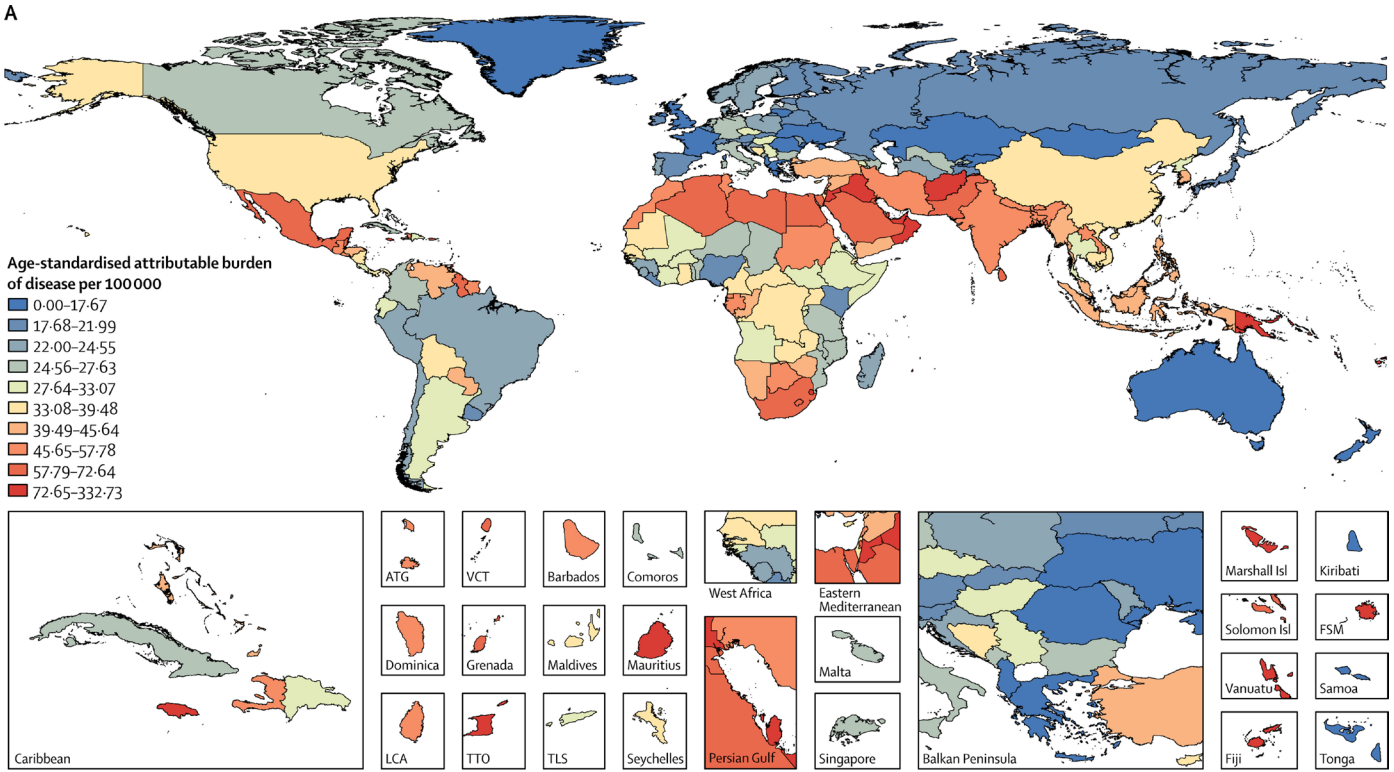
Motairek and Al-Kindi. Endocr Clin 2023

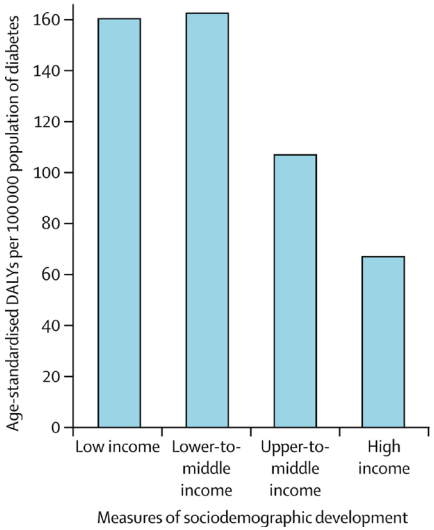
Non-Linear Relationships Between PM2.5 and Incident Diabetes



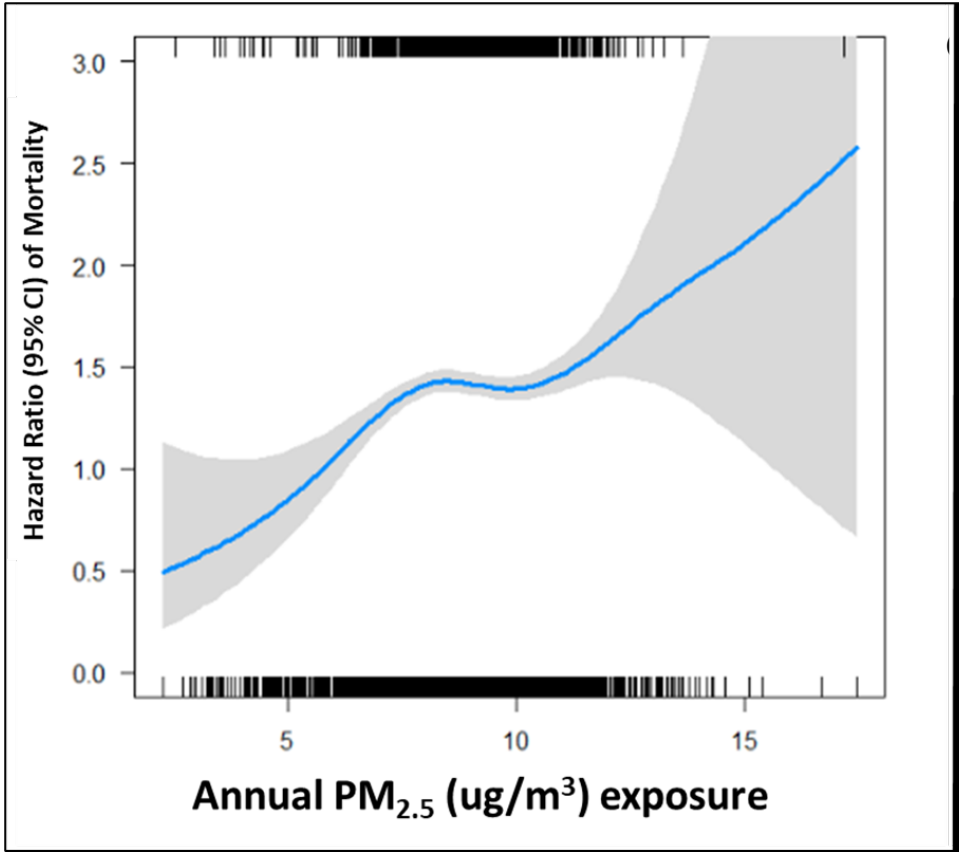
GBD 2019. Lancet Plan Health 2022

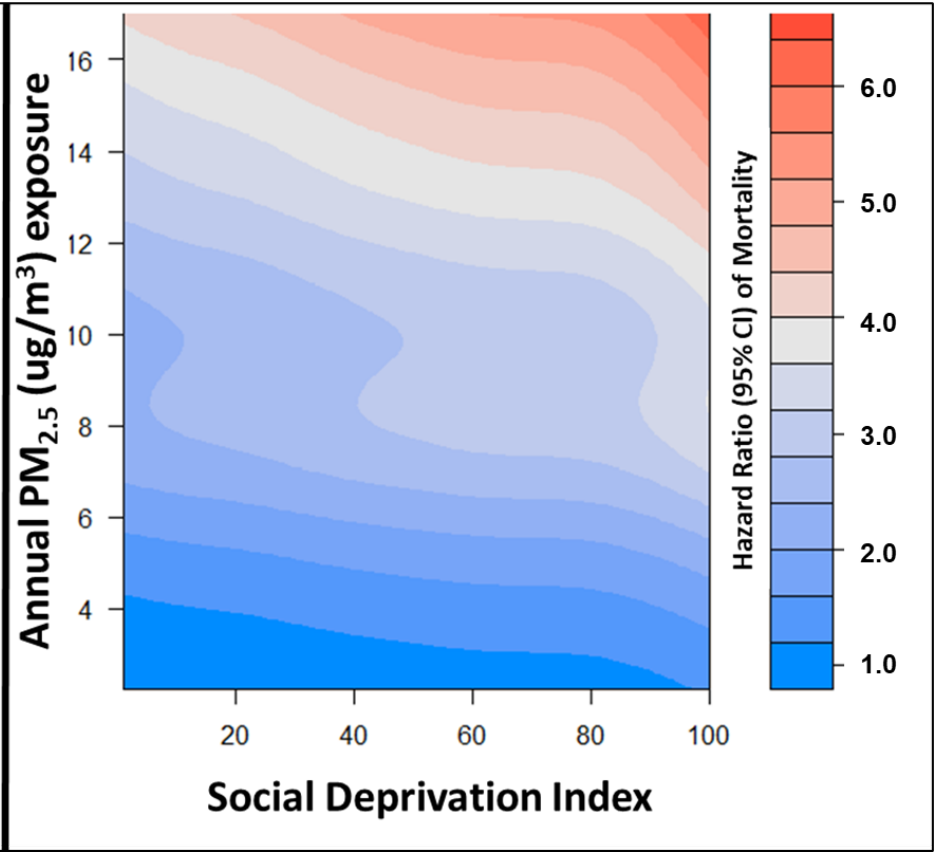
Global Burden of $PM_{2.5}$ Attributable Diabetes



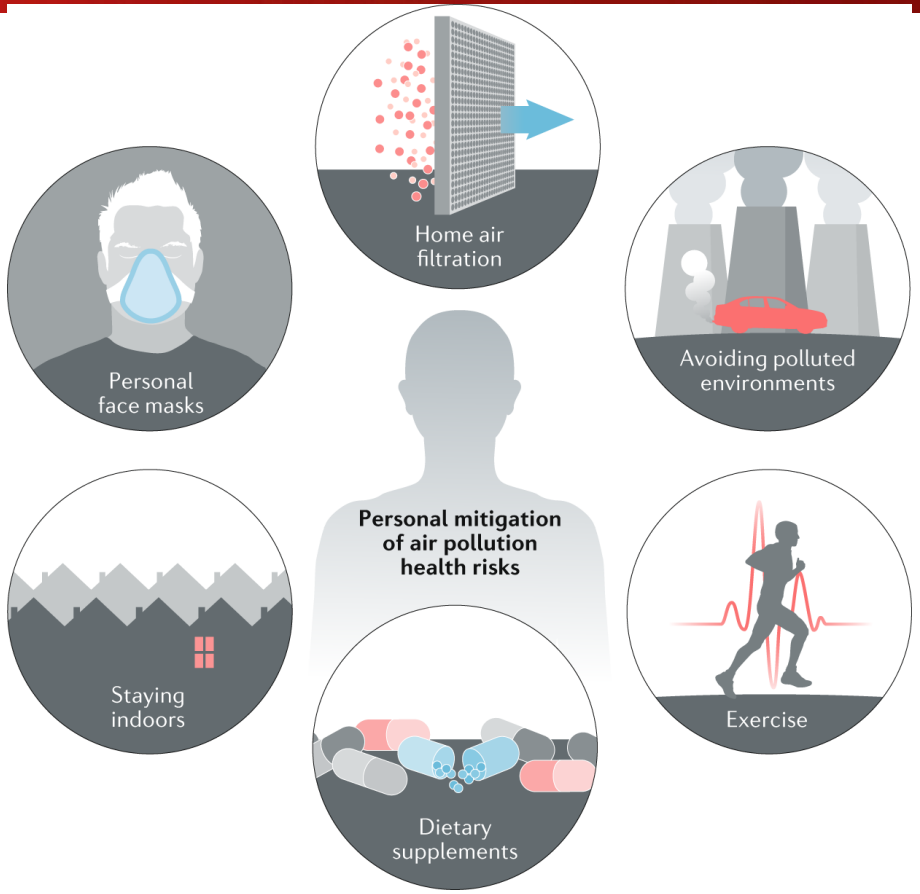


PM2.5 is associated with all-cause mortality in patients with T2D, particularly in Socially-Deprived Individuals





Personal Mitigation Strategies for Air Pollution



Air Pollution and Cardiovascular disease In Qatar, an interventional study to reduce Blood Pressure and Insulin Resistance: The APCIQ-BP trial

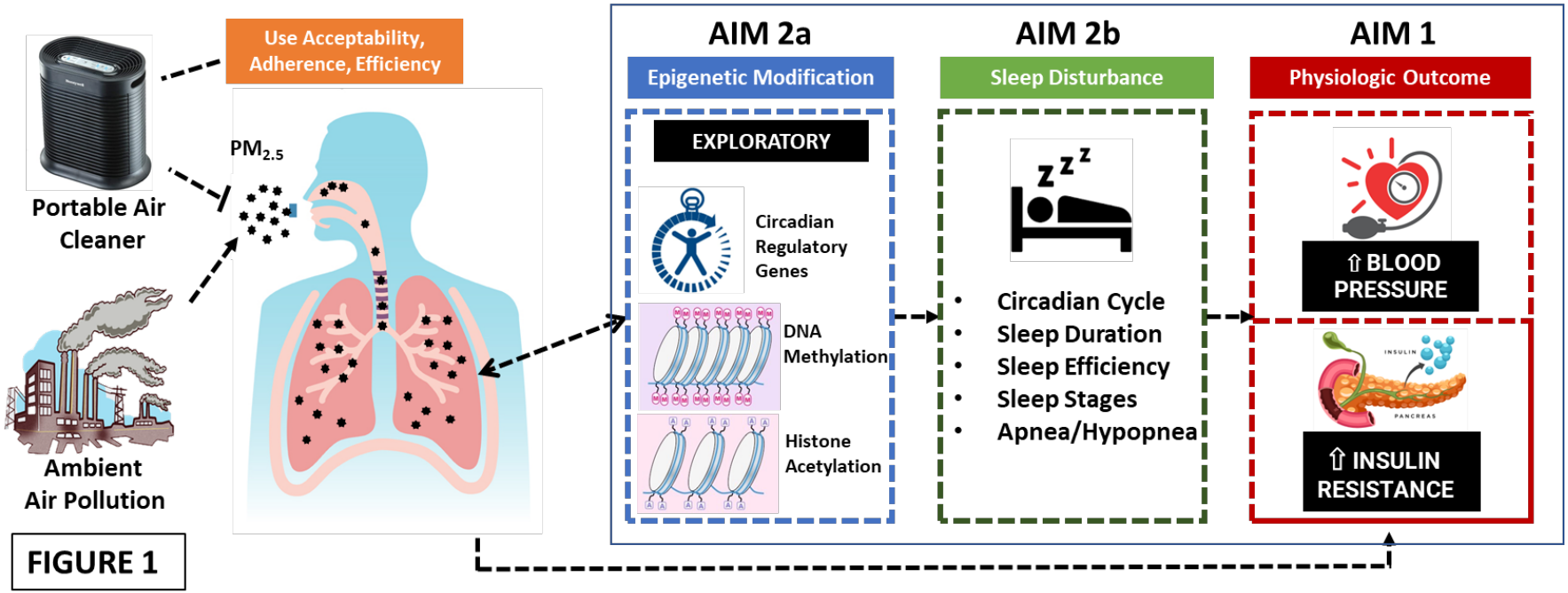
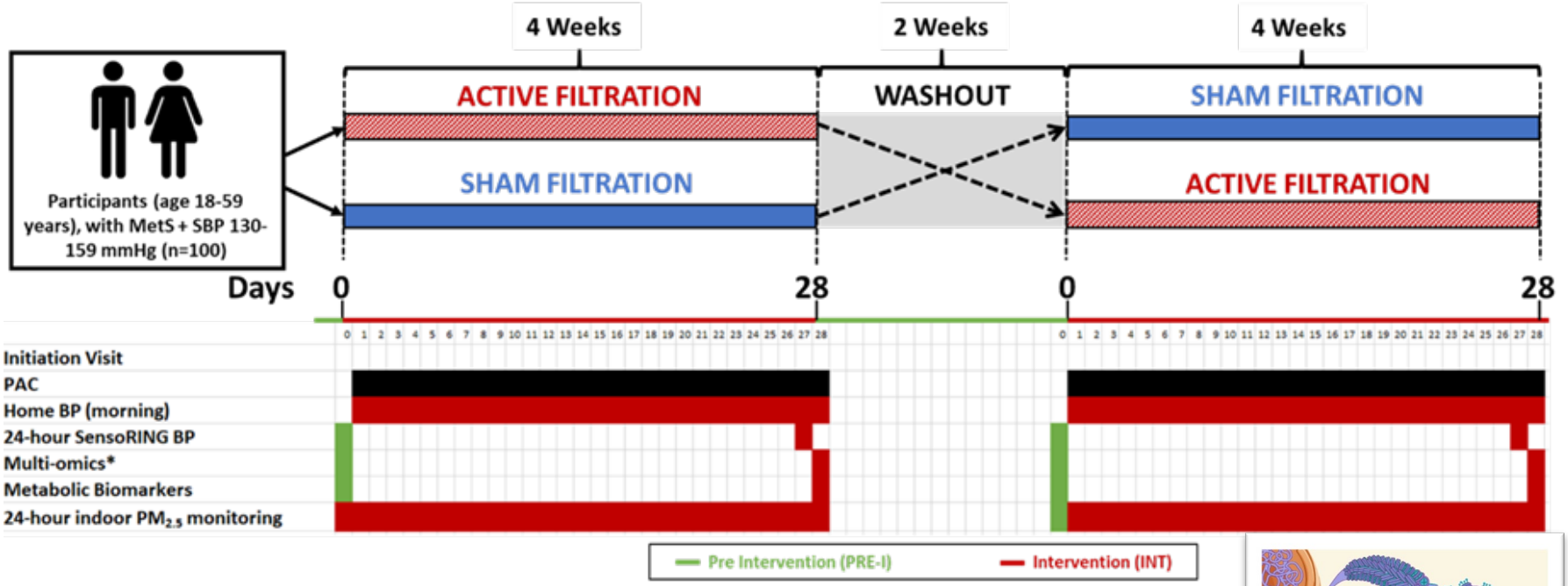
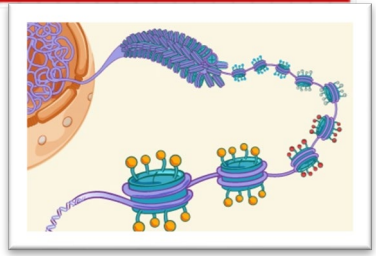


FIGURE 1

Air Pollution and Cardiovascular disease In Qatar, an interventional study to reduce Blood Pressure: The APCIQ-BP trial





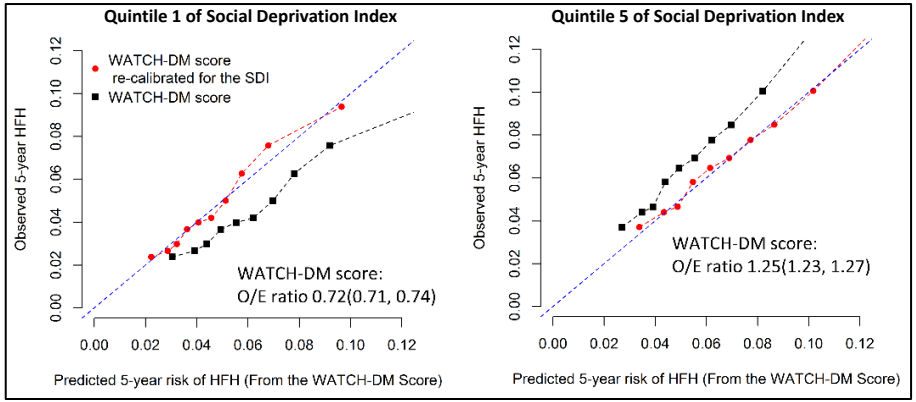
Qatar National Research Fund
Member of Qatar Foundation

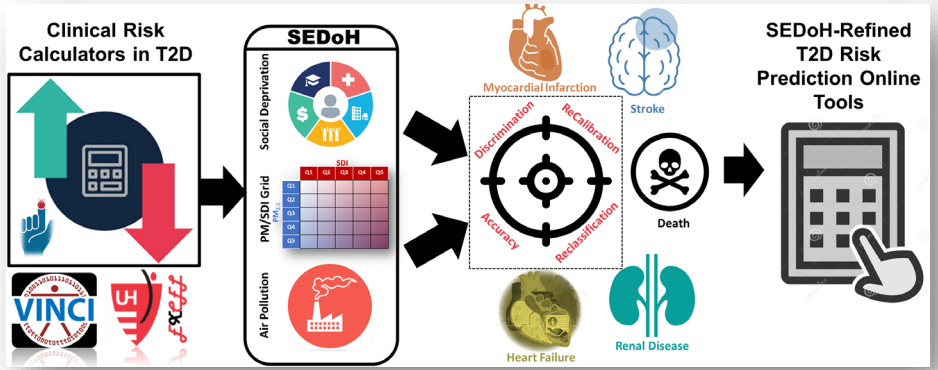
Weill Cornell Medicine-Qatar

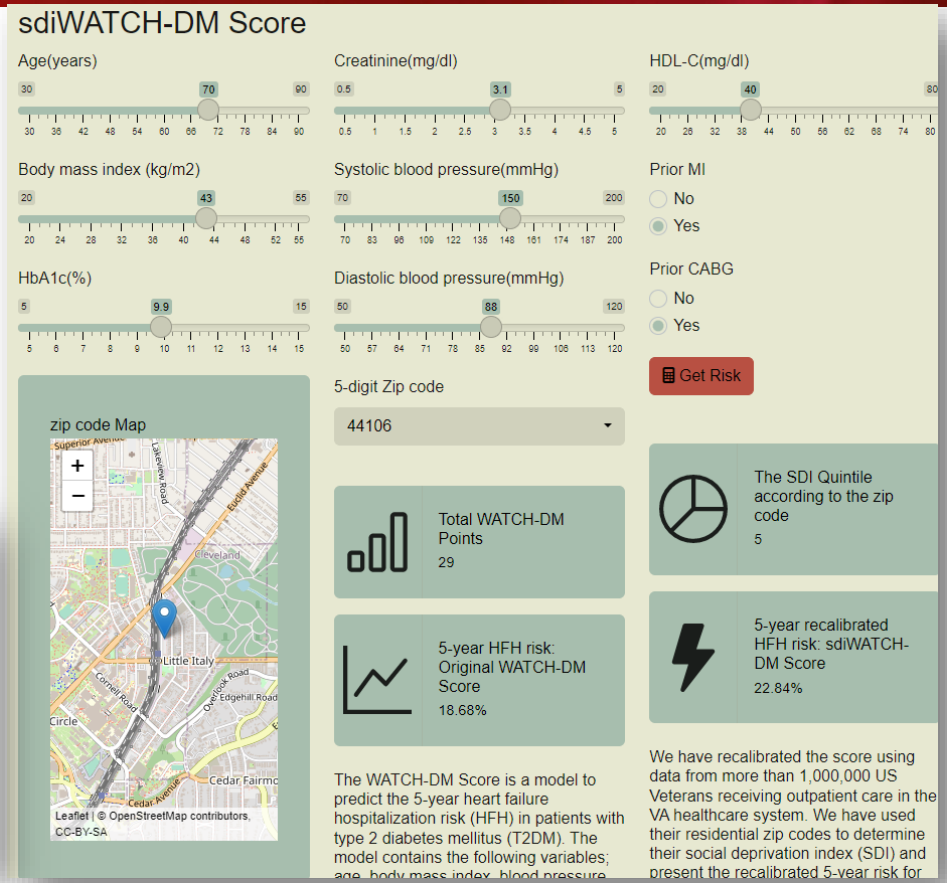
Case Western Reserve University EST. 1826

NPRP14S-0314-210047
PIs: Abi Khalil and Al-Kindi

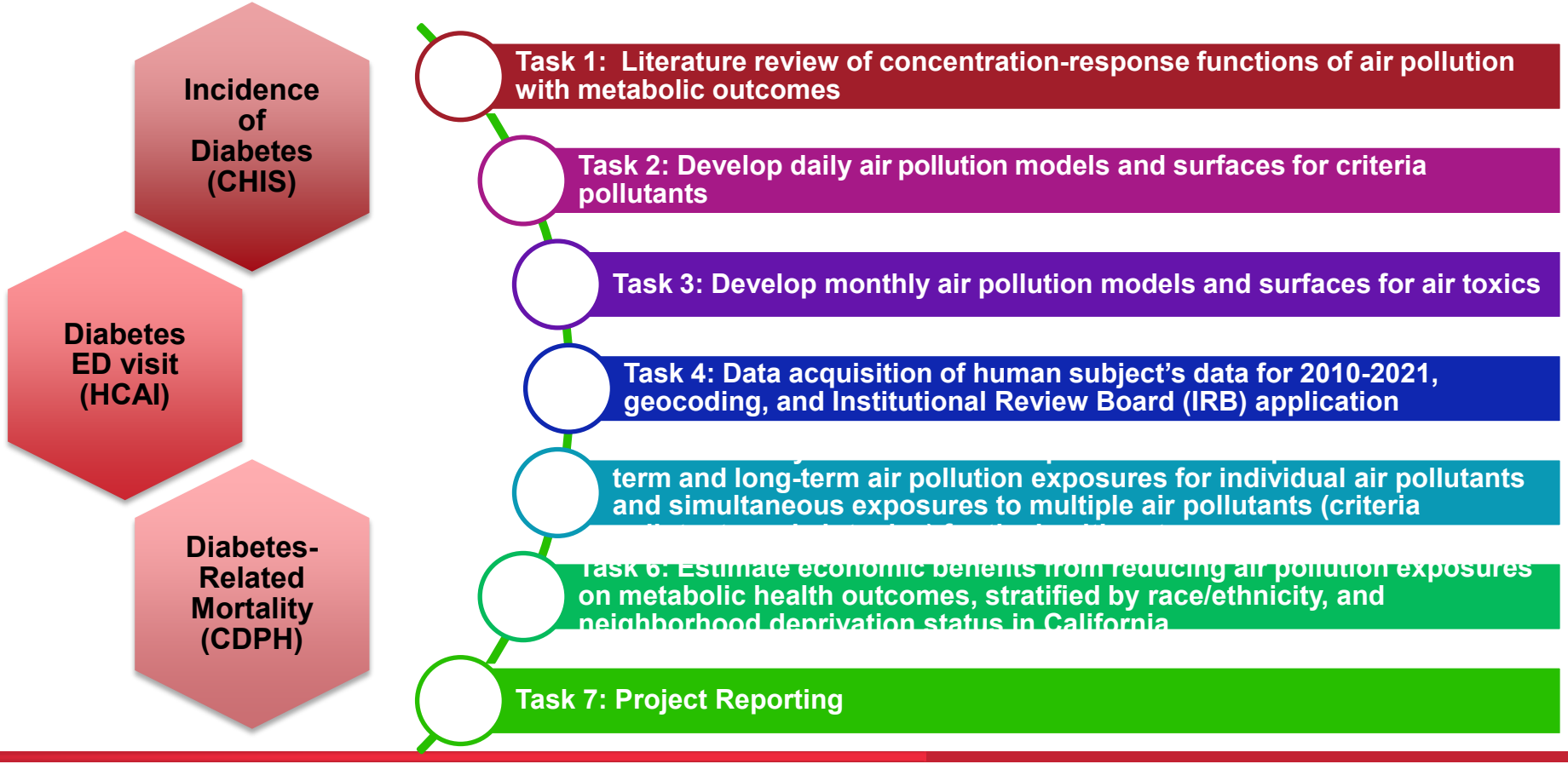
Incorporating SEDoH in Risk Prediction – The ZIP code Refined Risk Models in T2D







CARB Contract for Metabolic Health Outcomes (Lead: Jason Su, PhD – UCB)



Thank you!

Email: sadeer.al-kindi@case.edu

Funding

Wolfe Family Fund
Prentiss Foundation
U01CA260513
R35ES031702
P50MD017351
UH Informatics Award
Leonard Rosenberg Foundation

University Hospitals
Harrington Heart & Vascular Institute
Cleveland | Ohio

SCHOOL OF MEDICINE
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Reminders

- ADA-compliant slides will be posted on the website (registrants will receive a notice when they are posted).
- We will have a public comment period at the end of the meeting.
- Online public comment log will be open after the meeting (registrants will receive a notice when this is open for submissions).
- If you have any technical issues *during* the meeting, please email my colleague, Dr. Arash Mohegh, arash.mohegh@arb.ca.gov

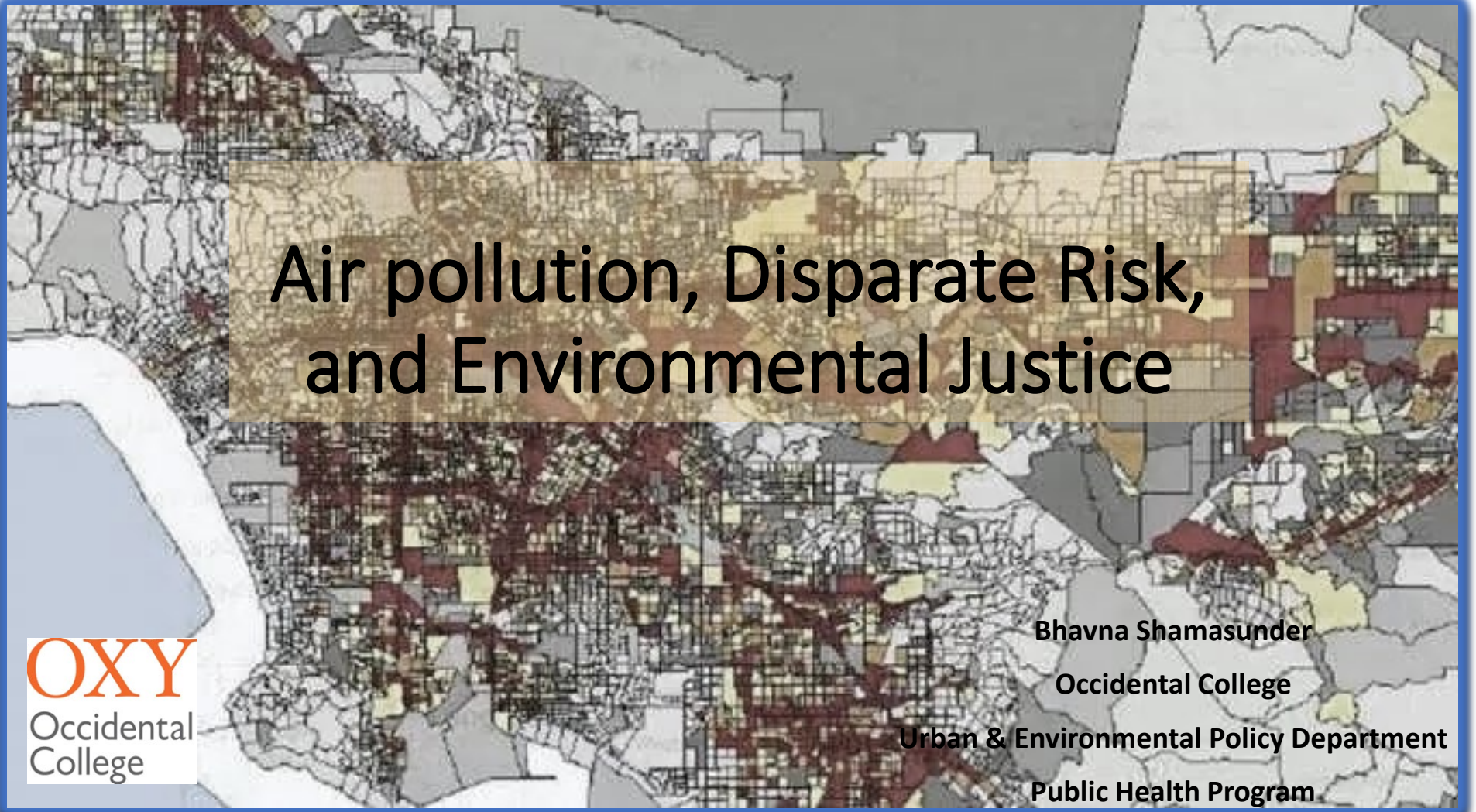
Bhavna Shamasunder, PhD, MES

Chair & Associate Professor, Urban & Environmental Policy

Occidental College

Dr. Shamasunder teaches and conducts research at the intersection of environmental health & justice with a focus on inequalities in chemical exposures faced by low-income communities and communities of color who live and work in urban and/or industrial environments.

CARB



Air pollution, Disparate Risk, and Environmental Justice

Bhavna Shamasunder

Occidental College

Urban & Environmental Policy Department

Public Health Program

OXY
Occidental College

Air Pollution & Cumulative Burden

- Communities have struggled for an approach to addressing disproportionate and cumulative burdens for decades.
- Through tools such as Cal Enviroscreen that have emerged from these efforts, we have a context for recognizing cumulative environmental and social harm, and we can better identify the communities impacted by **overlapping cumulative environmental, economic, and social burdens**
- A strong and growing body of research evidence demonstrates **disparities in air pollution exposures and in related health burdens** for communities of color, particularly Black and Latinx communities

Air Pollution and Environmental Injustice

While air quality has improved across the United States over the past decades (i.e. Fann et al, 2017; Sullivan et al, 2018)

Communities of color are still systematically exposed to higher levels of air pollution (i.e Demetillo et al, 2021; Kravitz-Wirtz et al, 2016)

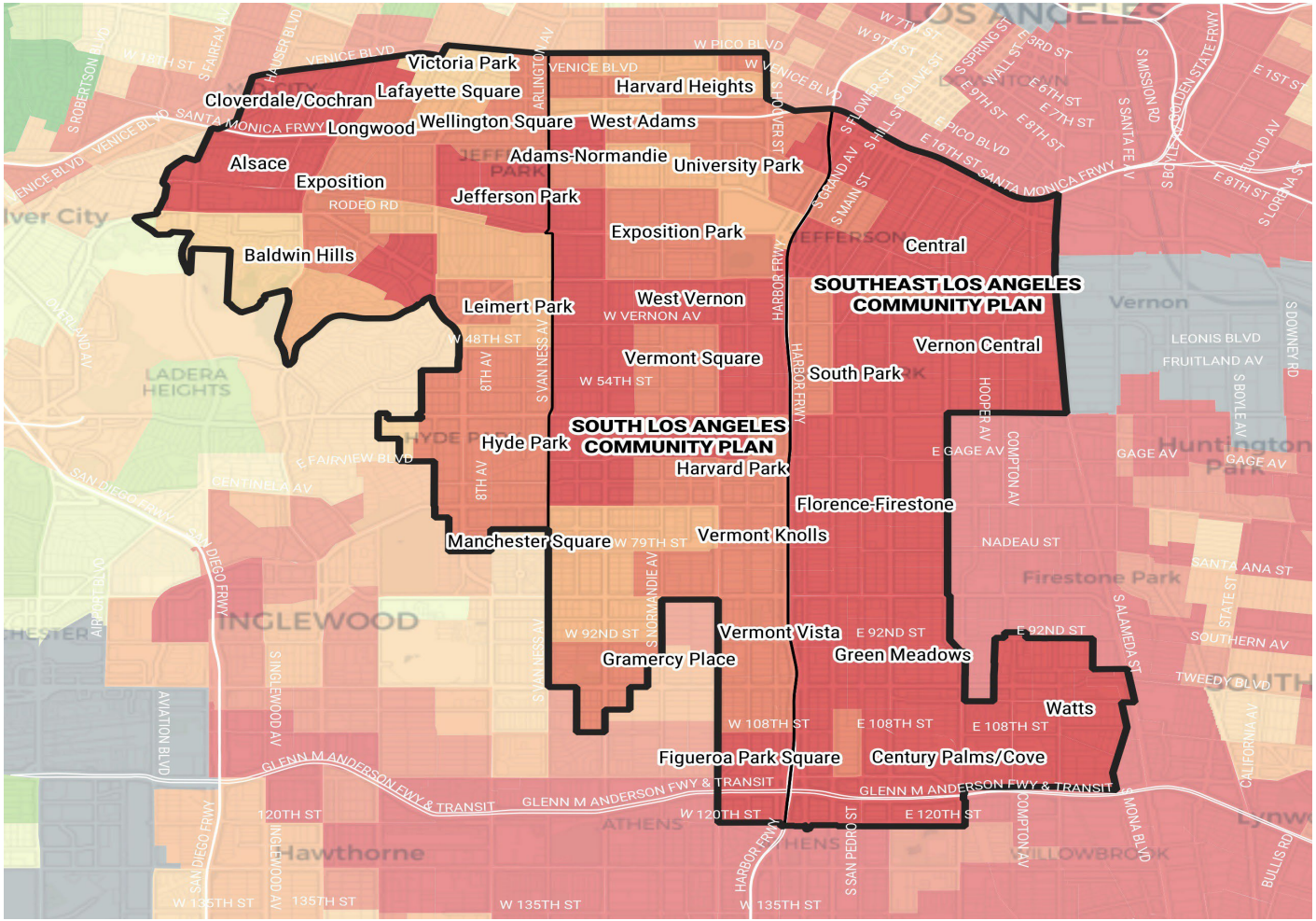
Communities of color are exposed to higher levels of air pollution at every income level (Liu et al, 2021; Clark et al, 2017; Tessum et al, 2021)

Local and Hyperlocal Air Pollution Patterns

- When we often consider air quality at the regional scale, we miss these important differences in air quality across a region.

- Studies such as mobile monitoring has observed **highly localized** air pollution patterns and **intraurban disparities** in air pollution (Chambliss et al, 2021).

- These studies suggest a **community centered approach** that accounts for hyperlocal and local scales via identifying neighborhood features that contribute to higher pollution, and constructing targeted interventions



South Central Los Angeles Community

Updated: 2.24.2021

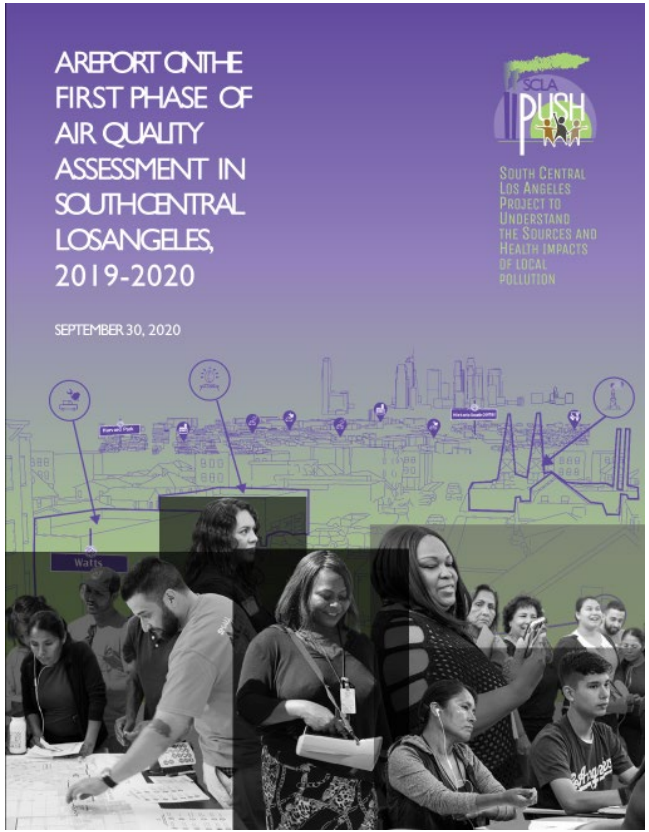
South Central Los Angeles Community Area

LACITY Community Plans

CalEnviron Screen 3.0 Results
Percentile of Vulnerability

- 0.0 - 0.0
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100

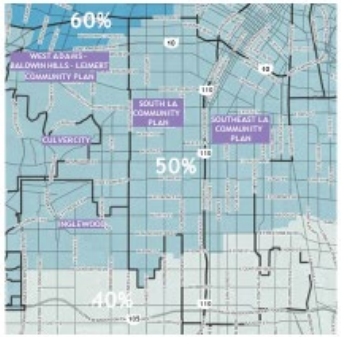
WHAT'S UP WITH THE AIR?
PUSHING FOR CLEANER AIR IN SOUTH CENTRAL LA!



This series of maps shows what we know about air pollution in South Central LA. The three types of pollution represented are ozone, diesel, and particulate matter. The darker the color, the higher the concentration of air pollution.

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 60%
- 60 - 70%
- 70 - 80%
- 80 - 90%
- 90 - 100%

FIGURE 2: CALENVIROSCREEN 3.0MAPS



OZONE

Concentration |CalEnviroScreen 3.0

DIESEL

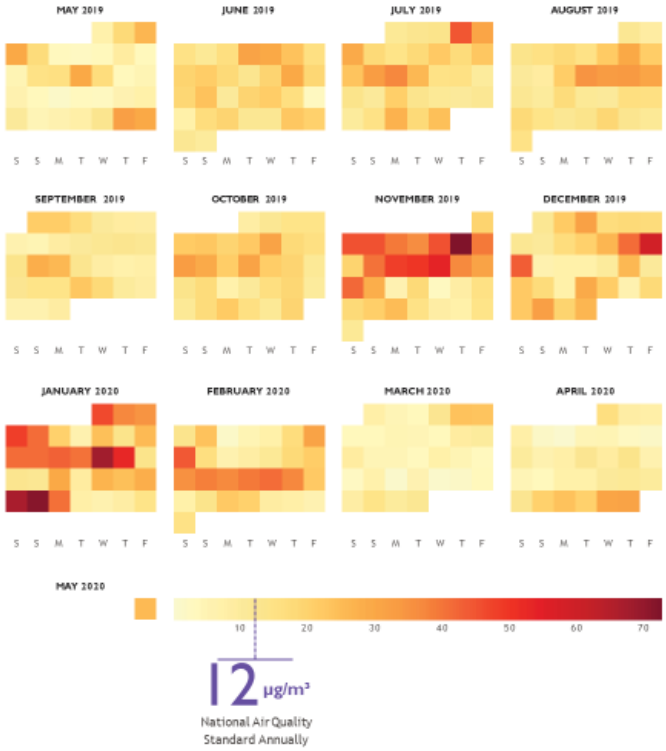
Particulate Matter |CalEnviroScreen 3.0

PM 2.5

Concentration |CalEnviroScreen 3.0

Among the monitors in South Central LA, the previous figure shows the average daily concentration of PM2.5 measured by all the PurpleAir monitors located within South Central LA. We observe the highest concentration in the winter months as shown on the calendar below figure 12.

FIGURE 12: AVERAGE PM2.5 FROM ALL PURPLEAIR MONITORS IN SOUTH CENTRAL LA BETWEEN MAY 2019 - MAY 2020



The EPA National Ambient Air Quality Standard (NAAQS) for PM2.5 averaged over a year is 12µg/m3. The standard for PM2.5 over a 24-hour period is 35µg/m3, meaning over any 24-hour period the average PM2.5 concentration should not exceed 35µg/m3. However, human health studies have observed harmful effects at concentrations even below 12 µg/m3.

TABLE 3: AIR QUALITY INDEX

PM2.5	Air quality	Who is at risk
0-12.5	Good	Air quality is considered satisfactory and air pollution poses little or no risk.
12.5-35	Moderate	Air quality is acceptable; however, a moderate health concern for people unusually sensitive to air pollution.
35-70	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects.
>70	Unhealthy	Everone may begin to experience health effects.

The results from the preliminary community air monitoring data show that the air quality in South Central Los Angeles is overall between moderate and unhealthy for sensitive groups. In the next section, we will describe how we corroborated the monitoring results by layering the data from the Mapping Workshop, Ground-Truthing Walks, portable and stationary air monitoring equipment into the **StoryMap** to demonstrate pollution and cumulative burden.

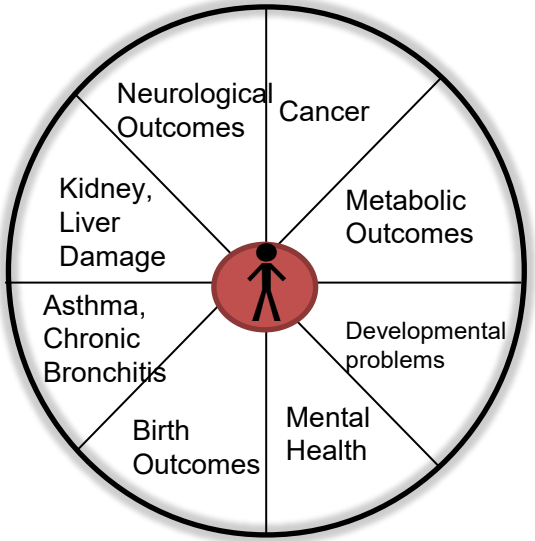
Air pollution in Southern California does not impact all communities equally. People of color in the United States are more likely to live in polluted neighborhoods or near facilities emitting PM2.5. Human exposure to particulate matter, even at low levels, is known to impact health across the lifespan. According to the EPA standards, while air quality may be considered acceptable at moderate levels, if communities are exposed for 24 hours there are health concerns.

Air pollution is linked with a range of adverse health outcomes, both acute and chronic

The speakers in this session have walked through the evidence on air pollution's links to worsened birth outcomes; neurodevelopmental outcomes; and metabolic outcomes

Air Pollution is linked with a range of adverse health outcomes but CARB only quantifies a few currently--Cardiopulmonary mortality; hospitalizations for heart and lung causes; emergency room visits for asthma

However**, we know that there is a growing body of likely to be causal, strongly suggestive, and suggestive evidence** for the endpoints discussed here today.



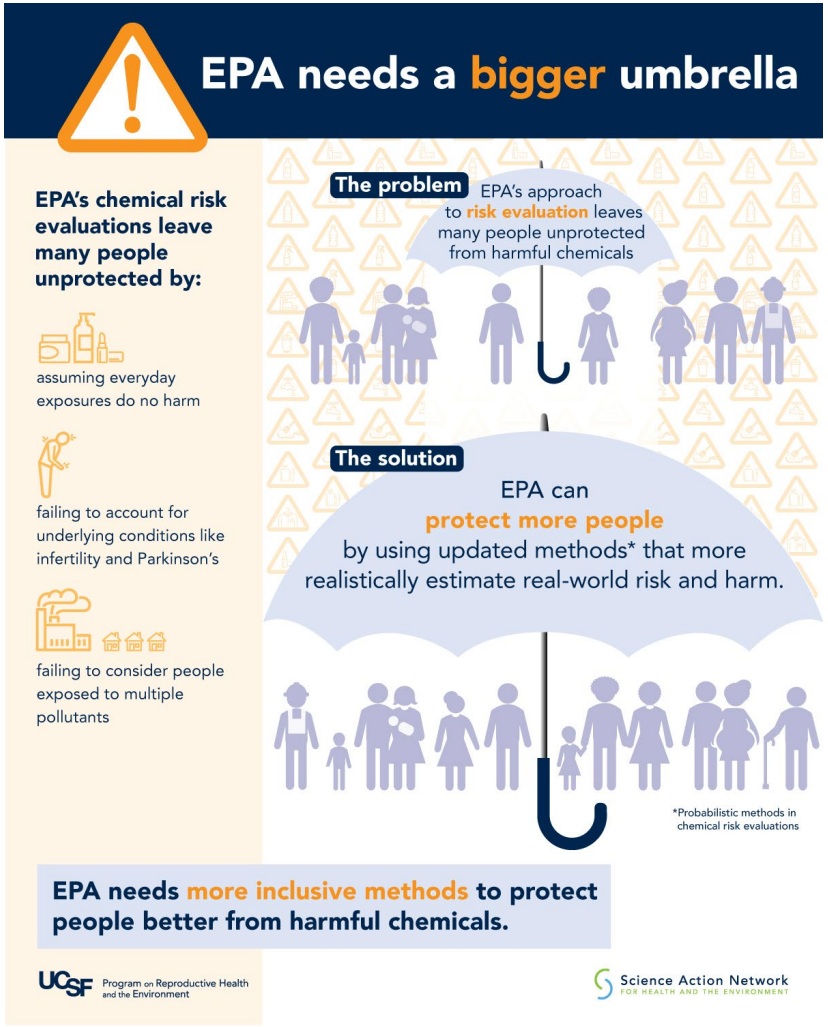
Supporting Environmental Justice

Further, air pollution is linked to exposures beyond PM 2.5

Noncancer Health Effects from Air Toxics are not included in CARB calculations. They could **implement a broader range of calculations for noncancer health effects** (such as discussed today), including not assuming there is a threshold for noncancer effects.

The 2004 Environmental Justice Action Plan by the CalEPA guided Boards, Offices, and Departments (including CARB) to "*Develop guidance on precautionary approaches"* along with *"guidance on cumulative impacts analysis".* We need to be doing both in tandem to implement environmental justice relevant approaches that will reduce air pollution related health disparities. **CARB should utilize the best available science for a range of health endpoints.**

A series of papers published by Program on Reproductive Health and the Environment are instructive for a "how" path forward, including supporting **better inclusion of science into risk evaluation and considering real world exposures**



Thank you (and to our SCLA PUSH partners)

bhavna@oxy.edu

SCOPE STRATEGIC COMMUNITY AGENDA

PSR LA
Physicians for Social Responsibility
Los Angeles

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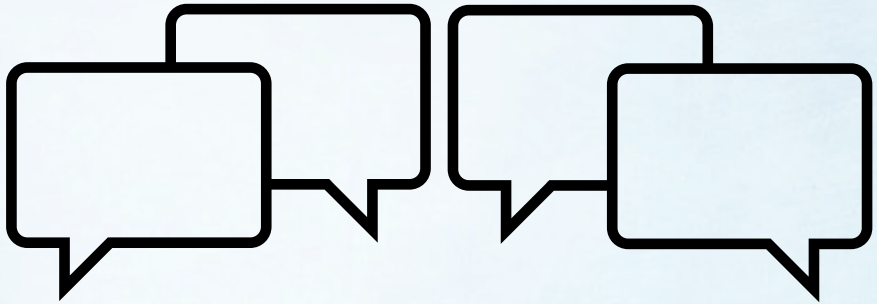
COMMUNITY HOUSING

SCLA PUSH

SOUTHERN CALIFORNIA ENVIRONMENTAL HEALTH SCIENCES CENTER

Omar Ureta

CHC Community Health Councils



Panel Discussion

Possible Topics for Health Outcomes & Community Health Issues Discussion

- Prioritization of health endpoints
- New approaches to health analysis
- Integration of cumulative impacts into health analysis
- How agencies could move forward to understand and act on health effects where less information is available

10-Minute Break

Return at:

11:05 AM Pacific Time

2:05 PM Eastern Time

Agenda

9am
- **Introduction**
- **Research on Air Pollution and Health Outcomes & Community Health Issues**
  - Presentations
  - Panel discussion with Scientific Health Experts

11am
- **BREAK (10 min)**
- **Approaches for Health Benefit Valuation**
  - Presentations
  - Panel discussion with Scientific Health Experts

12pm
- **Public comment**
- **Closing**

CARB

Presenters & Topics:

Approaches for Health Benefit Valuation

Pete Maniloff, PhD

US Environmental Protection Agency (US EPA)

Topic: Current US EPA methods

Al McGartland, PhD

US EPA

Topic: Emerging approaches

CARB

Pete Maniloff, PhD

Economist

US EPA, Office of Air Quality Planning and Standards

Dr. Maniloff is an environmental economist at the U.S. EPA. He works to improve how the Agency values changes in air quality.

Al McGartland, PhD

Director, National Center for Environmental Economics

US EPA

In his position at the EPA, Dr. McGartland advises senior leadership on regulatory analyses, science and environmental policy, while leading assessments on the benefits and cost-effectiveness of various environmental programs.

CARB

Towards More Complete Benefits Assessments

Al McGartland*

US EPA

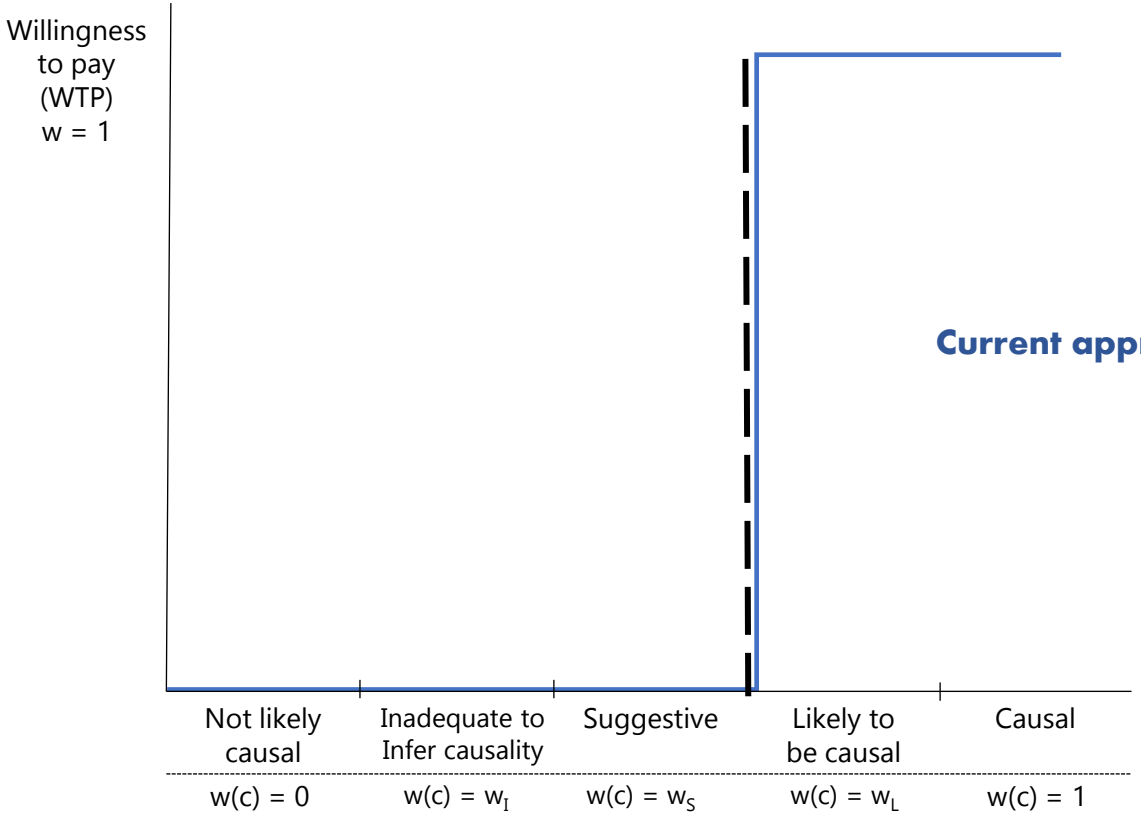
March 22, 2023

Director, National Center for Environmental Economics, US EPA. The views expressed here are solely mine and do not necessarily reflect the views of the U.S. Environmental Protection Agency.

Topics

- Quantification of health benefits: The “all in or all out “ problem.
- Willingness to Pay Or Cost of Illness; Willingness to Pay and Cost of Illness
- Capturing noncancer health endpoints: toxic chemicals and dose-response functions
- Quantifying additional benefits of air pollution reductions
  - Labor productivity
  - Cognitive impacts
  - Respiratory disease morbidity
  - Altruism

Everything that isn't "causal/Likely causal" is assigned zero benefit.

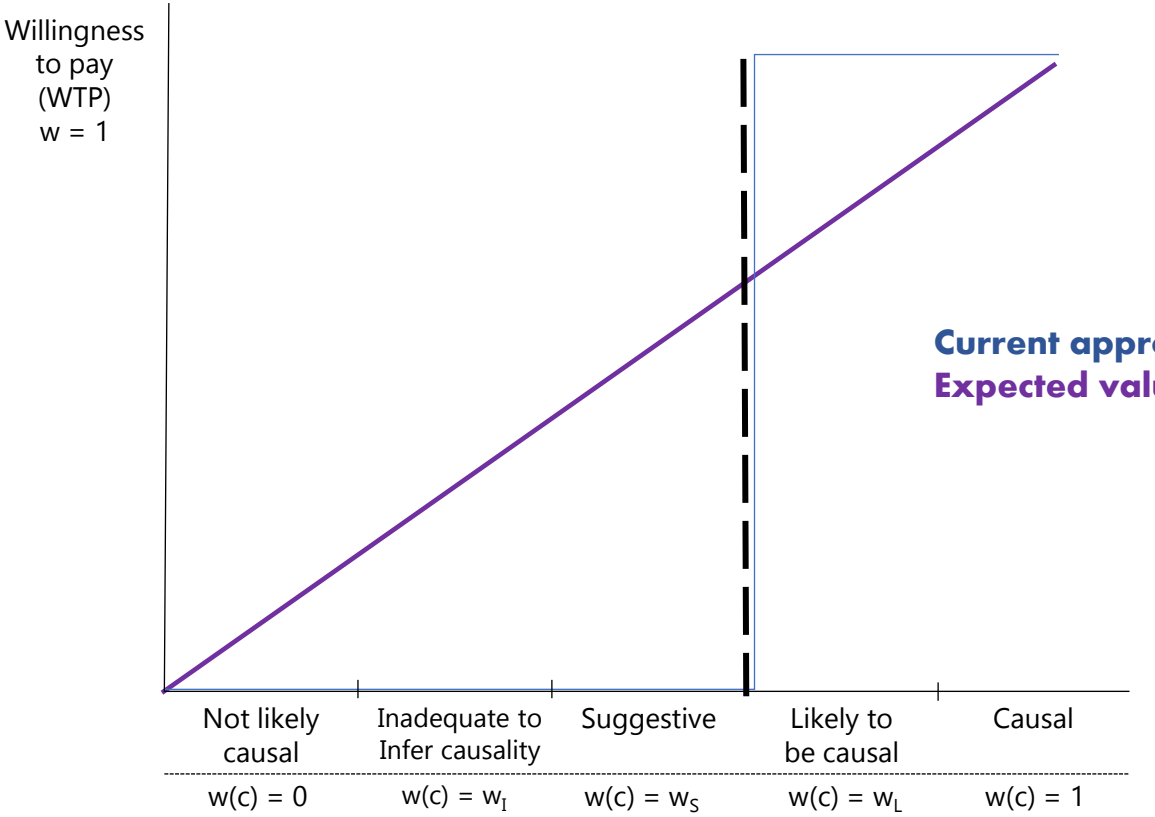


Current approach – "in or out"

When is Science Sufficient to Quantify Benefits?

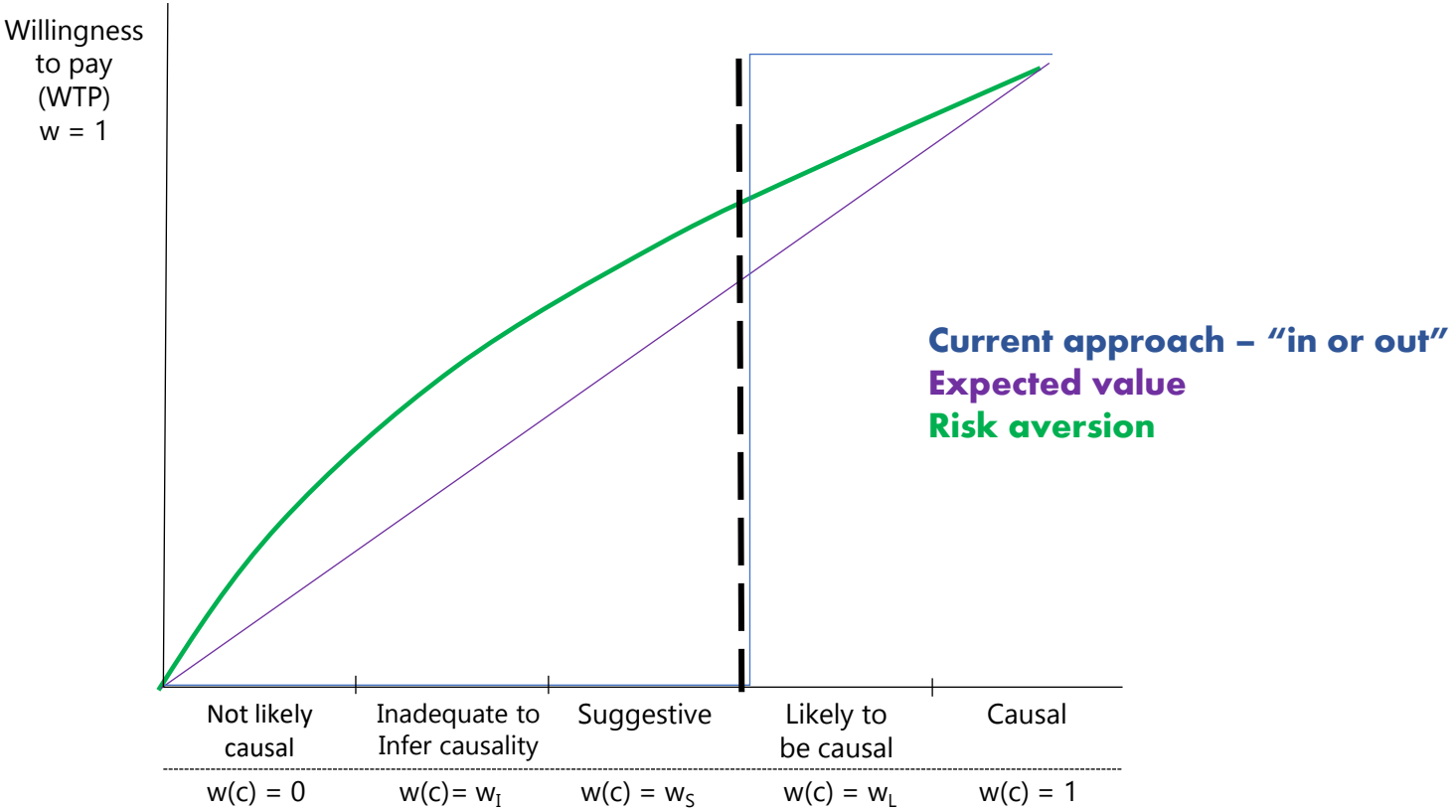
- In BCA, benefits are valued by what individuals would be **willing to pay** (WTP) for the environmental improvements resulting from the regulation (including reduced exposure to potential hazards)
  - Uncertainty does NOT imply no willingness to pay to avoid these risks; quite the opposite. (We buy insurance for all kinds of uncertain outcomes.)
  - With advances in causal inference, we have higher empirical confidence in causality.
- Current Practice:
  - Typically, quantify benefit endpoints deemed "causal" or "likely causal", but do not quantify "suggestive" endpoints (based on causality determinations in the NAAQS ISAs)
  - In a Sept. 2020 letter, the SAB recommended EPA consider potential inclusion of effects for which the relationship may be less certain, but the impact would be substantial

How to incorporate causality in valuation?



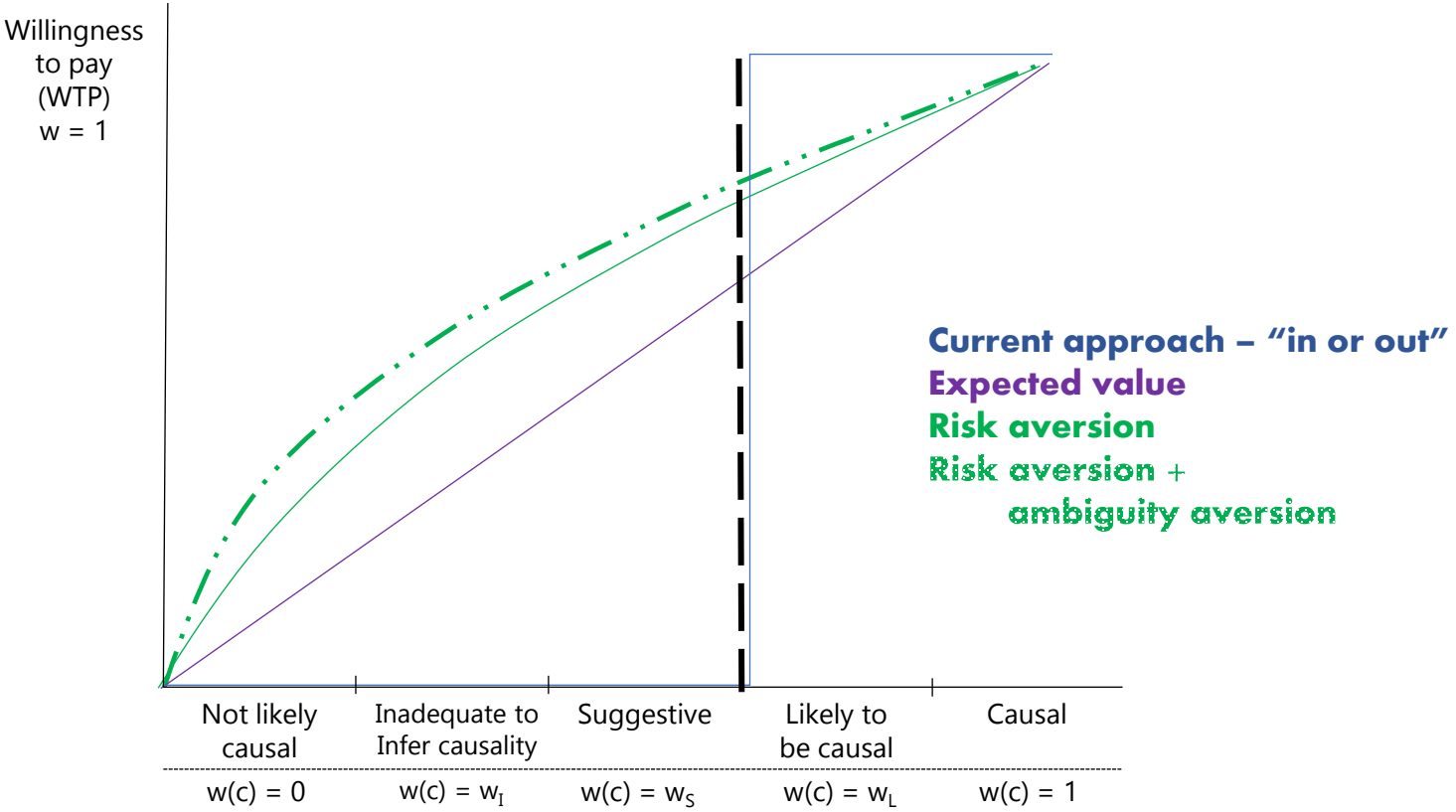
Current approach – "in or out"
Expected value

How to incorporate causality in valuation?



Current approach – "in or out"
Expected value
Risk aversion

How to incorporate causality in valuation?

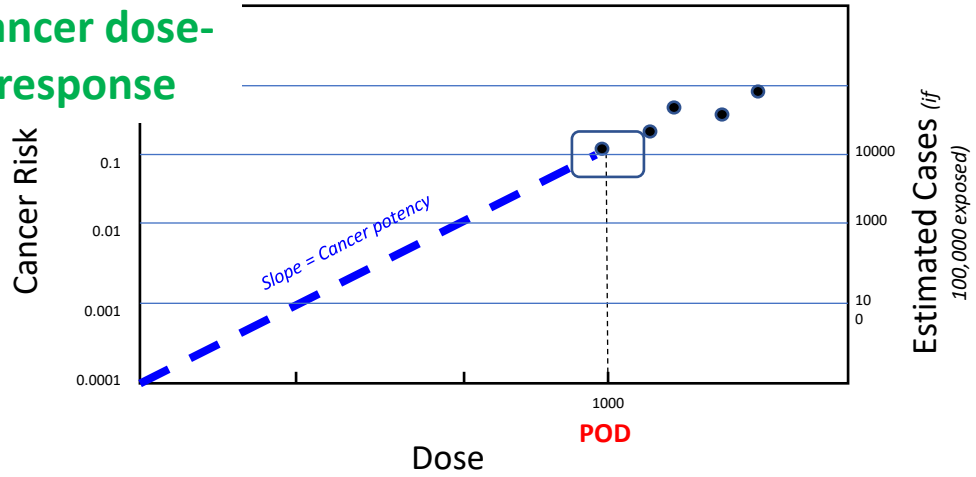


Noncancer Health Endpoints

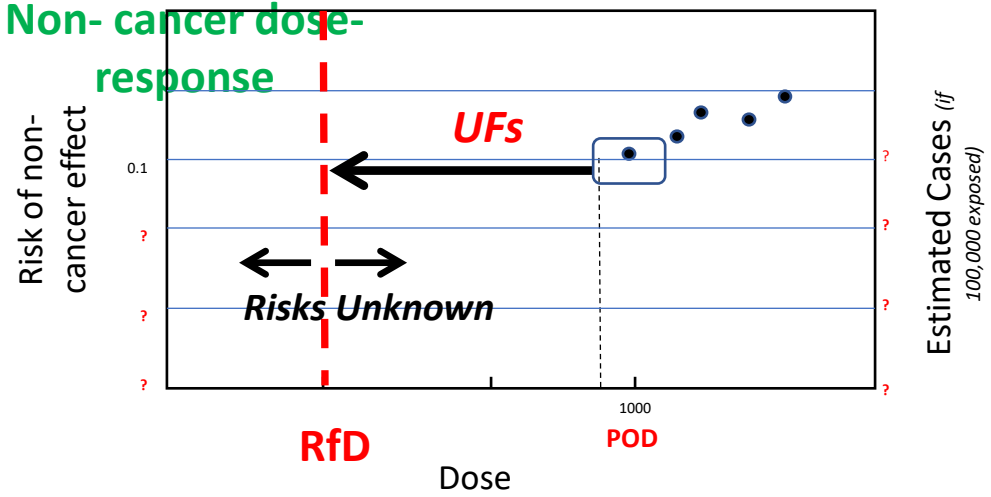
- “Historically, dose-response assessments at EPA have been conducted differently for cancer and non-cancer effects, and the methods have been criticized for not providing the most useful results. Consequently, non-cancer effects have been underemphasized, especially in benefit-cost analyses. A consistent approach to risk assessment for cancer and non-cancer effects is scientifically feasible and needs to be implemented.”

  -from NAS Science and Decisions report, 2009

Cancer dose-response



Non- cancer dose-response



Quantified Benefits

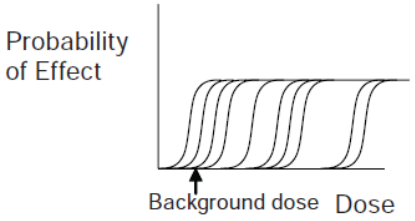
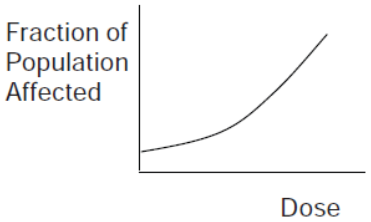
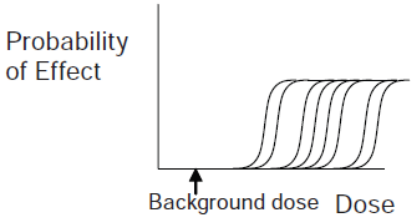
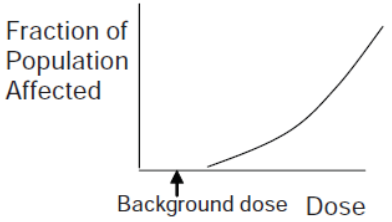
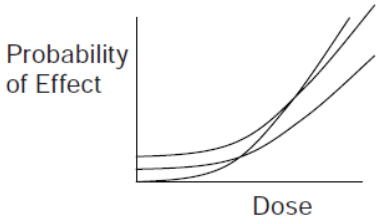
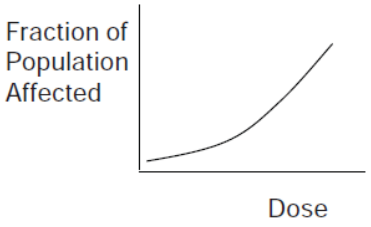
Criteria pollutants - usually epidemiology for D-R

Toxics & cancer - generally assume linear D-R to the origin

Unquantified Benefits

Toxics & noncancer - reference values or margin or exposure

Conceptual models describing individual and population dose-response relationships

Conceptual Models for Low-Dose-Response	Individual Dose-Response	Population Dose-Response
1. An individual's: Nonlinear The population: Linear		
2. An individual's: Nonlinear The population: Nonlinear		
3. An individual's: Linear The population: Linear		

PM effects quantified and monetized in Economic Analyses

Premature mortality from exposure to $PM_{2.5}$	Adult premature mortality from long-term exposure (age 65-99 or age 30-99)
	Infant mortality (age <1)
Nonfatal morbidity from exposure to $PM_{2.5}$	Heart attacks (age > 18)
	Hospital admissions—cardiovascular (ages 65-99)
	Emergency department visits— cardiovascular (age 0-99)
	Hospital admissions—respiratory (ages 0-18 and 65-99)
	Emergency room visits—respiratory (all ages)
	Cardiac arrest (ages 0-99; excludes initial hospital and/or emergency department visits)
	Stroke (ages 65-99)
	Asthma onset (ages 0-17)
	Asthma symptoms/exacerbation (6-17)
	Lung cancer (ages 30-99)
	Allergic rhinitis (hay fever) symptoms (ages 3-17)
	Lost work days (age 18-65)
	Minor restricted-activity days (age 18-65)
	Hospital admissions—Alzheimer's disease (ages 65-99)
	Hospital admissions—Parkinson's disease (ages 65-99)

From BenMAP-CE documentation and TSD for Estimating Benefit-per-ton of PM and Ozone

Willingness to Pay and Cost of Illness

Very few morbidity effects valued with WTP

Systematic undervaluation of morbidity effects

WTP is a more complete measure of value

WTP can be additive to COI values if both are estimated consistently

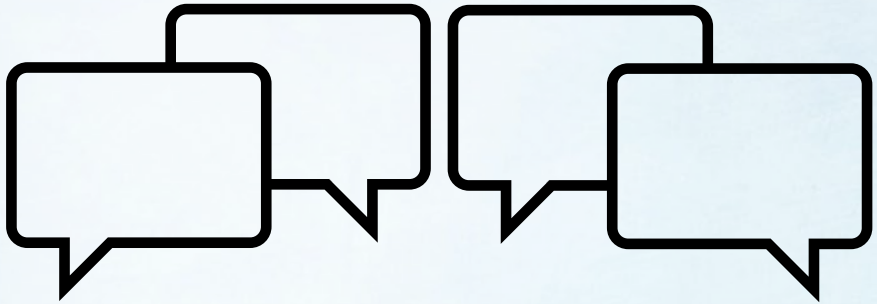
Towards More Complete Benefits Assessment

- The current literature could support quantification of additional benefits:
  - Labor productivity
  - Cognitive Impacts
  - Respiratory disease burden
  - Altruism related to disproportionate exposures

Moving Towards a More-Complete Accounting of Benefits

The current literature could support quantification of additional benefits:

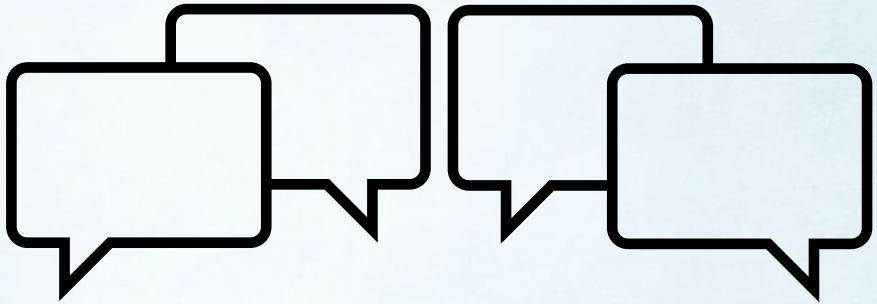
- Labor productivity
  - For a literature review, see Lu, "Air pollution: A systematic review of its psychological, economic, and social effects," 2020.
  - Labor productivity effects extend to politicians' speech quality (Heyes et al., "Pollution and Politicians," 2017).
- Cognitive Impacts
  - For a literature review, see Aguilar-Gomez et al., "This is Air: The 'Non-Health' Effects of Air pollution", 2022.
  - Test scores and later earnings (Ebenstein et al., "The Long-Run Economic Consequences of High Stakes Examinations," 2016).
  - Increased risk and accelerated progression of dementia (Bishop et al., "Hazed and Confused," 2022 and Li et al., "Long-term effects of PM2.5 components on incident dementia in the northeastern United States," 2022).
- Respiratory disease burden
  - Air pollution exposure increases hospitalizations related to the annual flu (Graff Zivin et al, "When Externalities Collide: Influenza and Pollution," 2022).
  - Poor air quality increased mortality from COVID-19 (Isphording and Pestel, "Pandemic Meets Pollution," 2021).



Panel Discussion

Possible Topics for Valuation Discussion

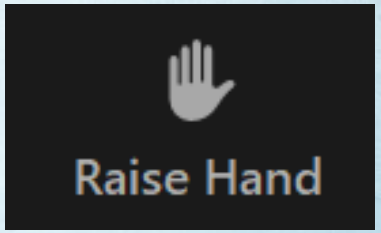
- New approaches to valuation
- Challenges and obstacles to valuation
- How to assess health effects that are not traditionally valued

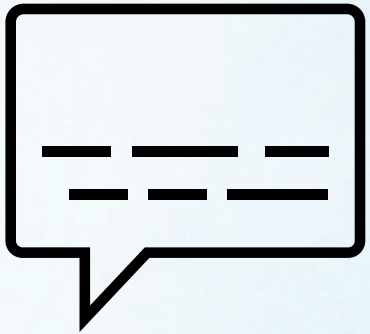


Public Comments

Format for Public Comment

- We will have a public comment period at the end of the meeting
  - To provide verbal comment, you may raise your hand to be added to the speaking queue.
  - Leave your hand raised until you are called upon to provide your comment.
  - Comments are limited to 2 minutes.
- Online public comment log will be open after the meeting (registrants will receive a notice when this is open for submissions).





Closing

Scientific Health Expert Panelists

Irva Hertz-Picciotto, PhD, MPH

Professor and Vice Chair for Research

Director, UC Davis Environmental Health Sciences Center

Dept of Public Health Sciences

UC Davis, School of Medicine

Michael Jerrett, PhD

Director, UCLA Center for Occupational & Environmental Health

Co-Director, Center for Healthy Climate Solutions

Professor, Dept of Environmental Health Sciences, UCLA Fielding School of Public Health

Rob McConnell, MD

Professor of Population and Public Health Sciences

Director, Southern California Environmental Health Sciences Center

USC

CARB

Penelope JE (Jenny) Quintana, PhD, MPH

Professor, Division of Environmental Health and Associate Director for Student Affairs

School of Public Health

San Diego State University

Bhavna Shamasunder, PhD, MES

Chair & Associate Professor, Urban & Environmental Policy

Occidental College

Tracey J. Woodruff, PhD, MPH

Alison S. Carlson Endowed Professor and Director, Program on Reproductive Health and the Environment & Environmental Research and Translation for Health (EaRTH) Center

UCSF

Thanks!

CARB